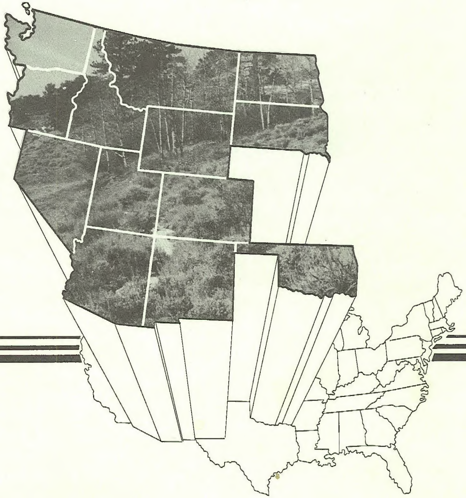
United States Department of the Interior
Bureau of Land Management

Wyoming May 1991

Final
Environmental Impact Statement
Vegetation Treatment on BLM Lands
in Thirteen Western States



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Prepared by
United States Department of the Interior
Bureau of Land Management

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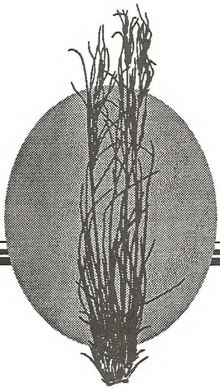

VEGETATION TREATMENT ON BLM LANDS IN 13 WESTERN STATES

( ) Draft (X) Final

U.S. Department of the Interior
Bureau of Land Management

Abstract

This Final Environmental Impact Statement (FEIS) assesses the environmental consequences of Federal approval of implementing a vegetation treatment program to manage a variety of vegetation species on public land in the Western United States. The program would apply to BLM-administered public lands in the 13 contiguous Western States of Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, North Dakota, Oklahoma, eastern Oregon, South Dakota, Utah, Washington, and Wyoming.

Based on the issues and concerns within the study area identified during the public scoping process and internal review, this EIS focuses analysis in the following areas:

- How each vegetation treatment method affects vegetation on a regional basis
- How each method affects fish and wildlife and their habitats
- How mechanical treatments and prescribed burning affect soils
- How all natural resources may be affected positively as well as negatively
- How herbicides and prescribed burning affect human health and safety

The FEIS analyzes direct, indirect, and cumulative impacts to various resources from the proposed vegetation treatment project and alternatives. It incorporates, and in some places modifies, analysis for the Draft EIS. In addition, it makes factual corrections from the draft document, responds to public comments or explains why comments do not warrant further agency response. This FEIS is not a decision document. Records of Decisions will be provided for each state after the final EIS is distributed.

EIS Contact

Comments on this EIS should be directed to:

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Date EIS Made Available to EPA and the Public

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ABBREVIATIONS AND ACRONYMS

ACEC	Area of Critical Environmental Concern
a.e.	acid equivalent
AMP	Allotment Management Plan
API	American Petroleum Institute
BLM	Bureau of Land Management, U.S. Department of the Interior
CDC	Centers for Disease Control
CDFA	California Department of Food and Agriculture
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
dbA	decibels
DEA	U.S. Drug Enforcement Administration
DEIS	Draft Environmental Impact Statement
DOE	U.S. Department of Energy
EA	Environmental Assessment
EEC	estimated environmental concentration
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ERMA	Extensive Recreation Management Area
ESA	Endangered Species Act of 1973 (16 U.S.C. 1531 et seq)
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FLPMA	Federal Land Policy and Management Act
FR	Federal Register
FWS	U.S. Fish and Wildlife Service
ha	hectare
HDT	highest dose tested
HSDB	Hazardous Substances Data Bank
IMP	Interim Management Policy
IPM	Integrated Pest Management
ITII	International Technical Information Institute
kg	kilogram
LC_{50}	Lethal Concentration
LD_{50}	Lethal Dose
LDT	lowest dose tested
LEL	lowest effect level
MATC	maximum acceptable toxicant concentration
mg	milligram
mg/L	milligrams per liter
mg/ft^2	milligrams per square foot

ABBREVIATIONS AND ACRONYMS

mg/kg	milligrams per kilogram
mg/kg/day	milligrams per kilogram per day
MOS	margin of safety
MTD	maximum tolerated dose
NEPA	National Environmental Policy Act
NIOSH	National Institute for Occupational Safety and Health
NLM	National Library of Medicine
noel	no observed effect level
NPS	National Park Service
NRC	National Research Council
NWCP	Noxious Weed Control Act
ODT	only dose tested
OSTP	Office of Science and Technology Policy
PAH	polynuclear aromatic hydrocarbons or polycyclic aromatic hydrocarbons
ppm	parts per million
PSD	prevention of significant deterioration
RMP	Resource Management Plan
RfD	reference dose
SRMA	Special Recreation Management Area
TLV	threshold limit values
TSP	total suspended particulates
U.S.C.	United States Code
UDS	unscheduled DNA synthesis
USDA	U.S. Department of Agriculture
USDC	U.S. Department of Commerce
USDHHS	U.S. Department of Health and Human Services
USDI	U.S. Department of the Interior
VRM	visual resource management
WHO	World Health Organization
WSA	wilderness study area
WSSA	Weed Science Society of America

EXECUTIVE SUMMARY

This final environmental impact statement (FEIS) describes and analyzes the impacts of a program the U.S. Department of the Interior, Bureau of Land Management (BLM), proposes to implement to treat vegetation on public lands in 13 Western States—Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, North Dakota, Oklahoma, eastern Oregon, South Dakota, Utah, Washington, and Wyoming. The impacts of BLM's program to manage vegetation in California and western Oregon have been covered in separate EIS documents and therefore will not be analyzed here. The impacts of BLM's program to manage noxious weeds in the states of Washington, Oregon, Idaho, Montana and Wyoming have been covered in a separate EIS document. See Appendix I-2 (1 thru 3) taken from the USDI-BLM, 1985 "Northwest Area Noxious Weed Control Program, final environmental impact statement." The list of noxious weed species that are being treated or might be treated is also in that document. The program is required to fulfill BLM's legal mandate, particularly the Federal Land Policy and Management Act of 1976, to manage public lands and their resources.

The vegetation treatment methods described in this final EIS include manual, mechanical, biological, prescribed burning, and chemical. Manual methods involve using hand or power tools; mechanical methods, heavy equipment, such as bulldozers; biological methods, plant-eating organisms, such as goats and insects; prescribed burning, controlled fire; and chemical methods (herbicides) to treat vegetation. Treatments would be made on selected sites to cut back or eliminate some part of the existing plant community or to eliminate selected plants. Treating vegetation is necessary to develop or restore a desired plant community, create biological diversity, increase forage or cover for animals, protect buildings and other facilities, manage fuels to reduce wildfire hazard, manage vegetation community structure, rejuvenate decadent vegetation, enhance forage/browse quality, or remove noxious weeds or poisonous plants. The areas that would be treated include rangelands, public domain forest lands, oil and gas sites, rights-of-way, and recreation and cultural sites.

In accordance with the National Environmental Policy Act (NEPA), this programmatic final EIS identifies impacts on the human environment by analyzing potential impacts of each vegetation treatment method and then, of vegetation treatment program alternatives, including the proposed program, that combine several methods.

PUBLIC PARTICIPATION

A primary consideration in developing the scope of this EIS was to determine which issues concern the public. When the decision was made to complete this vegetation treatment EIS, a public participation and coordination plan was developed to solicit public comments. A Notice of Intent was published in July 1988 describing the proposed program and soliciting comments in writing and through a number of public scoping meetings. Public participation is continuing as this FEIS undergoes public review and comment.

Many members of the public supported the proposed treatment program and recommended certain methods for specific target vegetation. Others were concerned about possible health effects or environmental damage from using herbicides and prescribed fire and about adverse effects from altering ecological systems in general. Because of the concern about using chemical herbicides and prescribed fire, particularly in terms of human health risk, those methods are given the greatest emphasis in the analysis. Separate detailed risk assessments, done on herbicides and on prescribed fire effects, are included as appendixes to this EIS. Emphasis is also given to potential program impacts on important vegetation communities of the West.

AFFECTED ENVIRONMENT

Methods and alternative programs are analyzed for potential impacts on 14 resource categories of the 13 Western States: vegetation, climate and air quality, geology and topography, soils, aquatic resources, fish and wildlife, cultural resources, recreation and visual resources, livestock, wild horses and burros, special status species, wilderness and special areas, human health and safety, and social and economic resources. Because impacts on many of these resources are likely to vary with the dominant type of vegetation on and near the treated sites, they are discussed where they apply in each of eight vegetation analysis regions of the Western States: sagebrush, desert shrub, southwestern shrub-steppe, chaparral-mountain shrub, pinyon-juniper, plains grassland, mountain/plateau grassland, and coniferous/deciduous forest.

EIS ORGANIZATION

Chapter 1 of this final EIS discusses the purpose and need for the proposed action, describes the methods of vegetation treatment and alternative programs, and summarizes the impacts of the programs. Appendixes C and E (Section E-2) give more detail about the treatment methods. Chapter 2 describes the 14 categories of resources in the EIS area that may be affected by the alternative programs; Chapter 3 discusses the impacts of the methods (Chapter 3, Section 1) and alternative programs (Chapter 3, Section 2). Chapter 4 describes the public's participation in the preparation of the EIS and Chapter 5 lists the EIS preparers and reviewers. Appendixes D and E present the detailed risk assessments on prescribed burning and herbicides, respectively.

ALTERNATIVES

Based on the concerns identified in scoping, the EIS analyzes the impacts of five alternative vegetation treatment programs (Table ES-1) that combine the various methods of treating vegetation. Alternative 1, the proposed action, which allows use of all available treatment methods—manual, mechanical, biological, prescribed burning, and chemical—to treat up to 372,000 acres of public lands annually, is the preferred alternative.

Alternatives 2, 3, and 4, respectively, limit herbicides to ground application, eliminate herbicide use, and prohibit prescribed fire. The acreages proposed for treatment under Alternatives 2, 3, and 4 are less than those under the preferred alternative because the terrain or other factors on some sites limit treatment to certain methods. Alternative 5, the No Action Alternative, continues BLM's existing level of vegetation management.

Because the proposed program covers such a wide and diverse area of the country, the FEIS does not analyze impacts on any specific site or group of sites. Instead, the FEIS provides an overview of the possible impacts of the different vegetation treatment methods and their combined use in the alternative programs, based on broad regional characteristics of the 13 Western States. Site-specific analyses tiered to this EIS will be done at the local level.

Implementing the selected treatment program would involve coordination with State and county agencies, public land lessees, and adjoining landowners to accomplish a vegetation treatment and to ensure that adequate safety measures are followed.

Table ES-1

Estimated Annual Average Acreage (in Thousands) by Treatment Method for Each BLM Vegetation Treatment Alternative

Method	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Manual	14.1	14.2	13.9	13.7	12.8
Mechanical	58.1	71.2	74.2	69.2	41.9
Biological	60.2	60.1	60.2	60.2	57.6
Prescribed Burning	97.8	132.3	136.4	0	92.7
Chemical	141.5	45.2	0	175.5	37.5
Total Acres	**371.7**	**323.0**	**284.7**	**318.6**	**242.5**

Note: Several factors may cause a reduction or increase in acreage in any given year, such as available funds, other workloads, revised land use planning, Threatened and Endangered species conflicts, cultural and visual resources and management concerns.

Alternative 1: The Proposed Action

Under the proposed action, all vegetation treatment methods would be available for use, to treat an estimated average 372,000 acres of public lands annually in the 13 States. This alternative is preferred because it gives BLM the greatest flexibility in specifying site treatments using the most effective and economical method available. The estimated average of 372,000 acres to be treated under the proposed action conforms to land use plan objectives and budget capabilities on public lands. Chemicals and prescribed burning would be used on most (64 percent) of the proposed treated acreage in this program. All safety requirements and project design features would be followed in accordance with BLM policy and Environmental Protection Agency (EPA) registration restrictions, as they would under all alternatives.

Alternative 2: No Aerial Application of Herbicides

This alternative would treat fewer acres (estimated average 323,000) because it would eliminate aerial herbicide application because of concerns about public health and potential damage to aquatic ecosystems from offsite chemical drift. Ground methods of herbicide application would be used for 45,000 acres. Manual and mechanical methods would be used on 14,000 and 71,000 acres, respectively. The acreage for biological treatment would decrease slightly from Alternative 1 at 60,000 acres, while prescribed burning would increase to 132,000 acres.

Alternative 3: No Use of Herbicides

Because of public health and worker safety concerns and a general concern about pesticides in the environment, no herbicides would be used under this alternative. This alternative would have the highest acreages specified for mechanical (74,000 acres) and prescribed burning (136,000 acres) treatments of any of the alternatives, but the overall treated acreage would be lower than Alternatives 1 or 2, with an estimated average of 285,000 acres treated.

Alternative 4: No Use of Prescribed Burning

Under this alternative, prescribed burning would not be permitted because of concerns about the effects of smoke on human health and the effects of burning on ecological systems. To compensate in part for the loss of fire as a tool, this alternative would have the highest annual average acreage (175,000) treated chemically, with biological being 60,000 acres. Herbicides would be applied aerially on 141,000 acres, and ground application methods would be used on 35,000 acres. Manual methods would be used to treat 14,000 acres, and mechanical methods would be used to treat 69,000 acres. The average estimated treated acreage would be 318,000 acres.

Alternative 5: No Action (Continue Current Management)

Under this alternative BLM would continue using the existing vegetation treatment program. An estimated average of 243,000 acres would be treated annually using manual, mechanical, biological, prescribed burning, and chemical methods. Approximately 62 percent would continue to be treated using prescribed burning and biological methods.

METHODS OF ANALYSIS

Impacts in this final EIS were evaluated by an interdisciplinary team of BLM and contract scientists that included experts in vegetation ecology in the Western States and in the human health and environmental effects of pesticides. Available studies on the effects of different treatment methods on western plant communities were researched and summarized and conclusions about program impacts were drawn from that body of scientific literature. The analysis of effects in the EIS is, in general, qualitative, but where impacts could be quantified, such as in the areas of human health and impacts of herbicides on wildlife, a quantitative risk assessment was done.

The herbicide risk assessment evaluated human and wildlife exposures and potential risks from using 19 different herbicides and two additives. However, after impact and risk assessment analyses, 17 are proposed for use in the vegetation treatment program. BLM has reexamined the risk assessment and examined additional data for amitrole. BLM has determined that amitrole is no longer considered for proposed use in this document. Amitrole will be deleted in the Record of Decision. Since drafting this document, producers are no longer manufacturing dalapon formulations registered for proposed use. Therefore, dalapon is no longer considered for use. However, information on all 19 herbicides is included throughout the document.

Human health effects evaluated included general systemic effects, effects on reproduction, cancer, heritable mutations, and effects on the nervous and immune systems. For the estimation of worker and public exposures from aerial and ground applications, both a typical and maximum likely rate of herbicide application was used for each type of program area application (for example, rangeland, right-of-way). The actual rate of herbicide application on a particular site is expected to be lower than the maximum rate used in the analysis and will depend on target vegetation species, time of year, application equipment, and herbicide formulation.

Herbicide formulations (Appendix M) may also contain one or more inert ingredients that may present health risks. BLM has determined that no formulation would be used in the program if it contains inert ingredients on EPA's List 1 (inerts of toxicological concern) or List 2 (inerts of high priority for testing), with the exception of petroleum distillate carriers, kerosene and diesel oil (their risks are evaluated in this analysis). However, if there is no product available that does not contain inert ingredients on EPA 1 or 2, then an herbicide product that does contain inert ingredients identified on EPA List 1 or 2 may be considered for use, with the understanding that the risk will be evaluated before treatment.

Environmental Consequences

Vegetation

Vegetation treatments would benefit as well as adversely impact both target and nontarget vegetation within the EIS area. Where individual plant species are the target, such as in noxious weed control, some injury or loss of nontarget vegetation may occur from all methods, particularly from herbicide use. Changes in species composition, plant community structure, species diversity, and productivity will result on sites where all vegetation is treated. Some species will be enhanced by treatment; others will be suppressed on the treated site. Treatment method and number of acres treated would determine the degree of vegetation impact. Positive impacts, the principal program objectives, would include wildlife habitat improvement, fuel hazard reduction, selection of desired timber species, and reduction or elimination of populations of noxious weeds.

Manual treatment methods should have no adverse impacts on nontarget vegetation for two reasons: 1) they are the most selective for target species and 2) they have limited application in the program because they are labor intensive and ineffective in controlling established creeping perennials, so they would not be used for large-scale rangeland improvement projects or for prescribed burning pretreatment.

Mechanical treatments generally kill woody species that do not have below-ground growing points. Root-sprouting shrub species will replace damaged canopies, and growth may actually be stimulated by mechanical treatments unless such species are treated by a method which severs them below the root crown. Herbaceous species are damaged by treatment methods that cause the most soil disturbance, in contrast to methods which cause more superficial soil disturbance and result in minimal damage. Plowing or root-cutting would generally require subsequent revegetation.

Normally mechanical treatment methods would affect woody plants more than herbaceous plants because root-sprouting woody species cannot quickly replace above-ground structure, whereas herbaceous species can replace their canopies annually. However during periods of drought, resprouting woody species such as rabbitbrushes, mesquite, and acacias can replace above-ground structures more rapidly than herbaceous species because they may have more extensive root systems to tap deep soil moisture.

Biological treatments with sheep, cattle, and goats would have slight impacts on a localized basis from feeding on nontarget vegetation to the extent that nontargets are interspersed with target species on a grazed site. Insect and pathogen treatments should have no impacts on nontarget plants because these techniques are species specific.

Prescribed burning could help prevent wildfires by removing fuel ladders and excess litter accumulations. Prescribed burning might decrease total plant productivity on a site but shift species composition from dominance by woody species to dominance by herbaceous species and stimulate new growth of certain woody species. Fire would significantly affect plant competition by changing the numbers and species of existing plants, altering site conditions, and requiring plants to reestablish on a site. Perennial plants with existing root systems usually have an advantage over plants that must develop from seed. There would be short-term reductions in productivity of many species but longer term desired results on target species. A particular plant species may or may not be desired on a treatment site, depending on land use objectives; therefore, the determination would be made on a site-specific basis according to individual goals of the management plan.

The impacts of chemical treatments would vary depending on how closely related the target and nontarget species are, the selectivity of the herbicide,

and the application rate. More sensitive annual plants would be affected to a greater degree than perennials, especially if killed before producing seed, although the ability of plants to maintain viable seeds in the soil for several years should reduce the susceptibility of a plant species to herbicides.

Adverse impacts discussed above for all vegetation treatment methods could apply under Alternative 1. The overall positive impacts would be to achieve desired vegetation communities on treated rangeland and forestland sites, create stratified age structure dynamics in some shrublands for wildlife habitat improvement, reduce hazardous fuel buildup, reclaim certain areas to native perennial vegetation, reduce populations and spread of noxious weeds, remove vegetation that was a potential hazard to recreationists, and maintain safe conditions in rights-of-ways and oil and gas facilities. Specific areas of some shrub-dominated rangeland communities would have higher production of herbaceous vegetation mixed with shrubs. Alternative 1 offers the greatest degree of flexibility of any alternative for general vegetation management and for control of noxious weeds and poisonous plants.

Under Alternative 2, elimination of aerial chemical treatments would reduce the potential for offsite impacts on nontarget plants. Desired vegetation communities prescribed in land use or activity plans would not be achieved in some areas where treatment would be foregone because other treatments could not be substituted. Managerial ability to select the most appropriate and cost-effective treatment method for rangeland situations would be reduced under this alternative. Most treatments for riparian areas, recreation areas, oil and gas facilities, and most rights-of-way would not be affected by this alternative. Noxious weeds would continue to be controlled in most infestation situations. More prescribed fire would be used than under the Proposed Action. Because aerial chemical treatment would not be available, target areas for treatment of shrub and brush species that do not carry fire might not be treated at all. Noxious weeds would be controlled, but overall management effectiveness would be less than under Alternative 1.

With no use of herbicides under Alternative 3, impacts discussed above for chemical methods would not occur. Desired vegetation communities prescribed in land use plans or activity plans would not be achieved in some areas where treatment would be foregone because other treatments could not be substituted. Managerial ability to select the most appropriate and cost-effective treatment in nearly all situations would be limited under this alternative. Most noxious weeds would not be controlled, and safety hazards from proliferation of undesired plants could develop on on oil and gas facilities, rights-of-way, and recreation areas because of ineffective treatments by other methods. Reclamation efforts in saltcedar and cheatgrass communities would be far less effective relative to the Proposed Action.

More acreage would be treated with chemicals under Alternative 4 than under any other alternative. Therefore, the impacts of chemical methods would apply to the greatest degree here, but the impacts of prescribed burning would not. The likelihood of catastrophic wildfire increases without the use of prescribed fire. Vegetation management objectives in land use or activity plans would not be met in specific areas. Managerial ability to select the most appropriate and cost-effective treatment method for rangeland situations would be limited under this alternative. There will be long-term undesirable effects from no use of prescribed fire in nearly all vegetation analysis regions, where fire was historically an ecological factor.

Fewer acres would be treated under Alternative 5 than under any other alternative. Vegetation management objectives in land use or activity plans would not be met in specific areas. Although all treatment methods would be available under this alternative and the impacts discussed under all methods would apply here, program use of herbicides would be more limited than under Alternative 1, and fewer acres would be treated with herbicides than under any other alternative except Alternative 3. Controlling noxious weeds and poisonous plants would not be as effective as under Alternative 1.

Climate and Air Quality

The most significant impact to air quality would be moderate, short-term increases in dust and exhaust generated by manual and mechanical treatment methods, smoke and particulates from prescribed burns, and chemical drift from herbicide applications. Air quality standards would not be violated. The aircraft and equipment used in vegetation treatments would create temporary, localized noise. Alternative 3 would cause the highest overall impacts to air quality because it involves the highest acreage of burning. Alternative 4 should have the fewest impacts because no acreage would be burned (although smoke impacts from wildfires would increase).

Geology and Topography

Because treatments are likely to affect only the soil surface on relatively small geographic areas compared to the extent of geologic and major topographic features, none of the alternatives should impact these resource elements.

On a smaller scale, local topography could be affected to some extent where significant vegetation removal from a treated site leads to wind or water erosion. Proper management practices should prevent this from occurring on most sites.

Soils

The impacts of manual and biological treatment methods on soils would be negligible. Chemical treatments would not impact soils directly but could indirectly affect soil microorganisms. Mechanical and prescribed burning treatment methods have the greatest potential to impact soils. Alternative 3 has the greatest potential to impact soils because it has the highest combined acreage of mechanical and burning treatments. Alternative 4 would have the fewest impacts on soils because no prescribed burning would be used and relatively few acres would be treated mechanically.

Aquatic Resources

Manual and biological treatment methods would have a negligible impact on aquatic resources provided that Standard Operating Procedures (SOPs) are followed. Mechanical and prescribed burning treatments would increase short-term erosion. Sedimentation from these treatments could be minimized using SOPs and Best Management Practices (BMPs). Herbicide treatments could cause drift onto surface water, however, the SOPs would minimize this occurrence. Contamination potential exists for ground water from herbicides if SOPs are not followed. The use of the screening procedure given in the SOP should eliminate any ground water contamination from herbicides. Alternative 3 could cause the greatest impacts because it has the highest combined acreage of mechanical and prescribed burning treatments. Alternative 4 should have the least impacts because no prescribed burning would be used and relatively few acres would be treated by mechanical methods. More acres are treated by herbicides than under any other alternative, thus increasing the potential for ground and surface water contamination because of accidents.

Fish and Wildlife

Fisheries and riparian resources are not likely to be significantly impacted under any of the treatment methods or alternatives, if suggested mitigation is incorporated into the individual treatment proposals. Impacts to wildlife from forage and habitat reductions would likely be temporary and localized, except when permanent vegetation type-conversion is planned.

There will be a permanent or long-term change in the wildlife community using these type-conversion areas. Alternative 1 would have the most potential beneficial impacts on wildlife because the best and/or least impacting method for treating a specific habitat would be available for use. Alternative 1 also has the greatest potential for adverse impacts. Appropriate mitigation and control of aerial spraying are necessary to avoid adverse impacts, as are application of proper project designs on site-specific treatments. The most acres of current habitat will be disturbed.

Alternative 2 would have impacts similar to Alternative 1, except the potential adverse impacts from aerial spraying are eliminated, and competition between noxious weeds and native forage plants would be greater with the less effective control of the noxious weeds. Few projects directly beneficial to wildlife would be foregone. Under Alternative 3 the potential adverse effects of herbicides on fish and other wildlife would be eliminated. Impacts from prescribed burning would largely be substituted for impacts from herbicides. Fewer acres of beneficial projects, available in Alternative 1, would be accomplished in this alternative. Fewer acres of current habitat would be disturbed than in Alternatives 1, 2, and 4. The least acres of noxious weeds would be treated, and an associated loss of native forage plants would occur. There would be no effective method for treating saltcedar-invaded areas to restore native riparian areas.

In Alternative 4, with no use of prescribed fire, one of the most practical and cost effective methods of wildlife habitat improvement is eliminated. Excess plant and timber residue, as a result of other treatment methods, would not be effectively removed and movement of some wildlife species would be inhibited. The most acres of aerial and total herbicide application would occur in this alternative, with the highest potential for adverse impacts to wildlife. Also, many acres of herbicide application would be less effective because it was not considered the preferred method of control.

Alternative 5 would have fewer impacts from treatments because fewer overall acres would be treated under this alternative. No potential adverse impacts from herbicide application would occur in some states where herbicide use is restricted. The fewest acres of current wildlife habitat would be disturbed in this alternative, and the least acres of beneficial habitat improvements accomplished.

Cultural Resources

Some of the proposed vegetation treatments, particularly mechanical, could impact cultural resources and traditional lifeways; however, the exact probability of damaging cultural resources

and lifeways cannot be determined at the level of analysis possible in a study of this scope. No proposed treatment project will be authorized until specific impacts to cultural resources and lifeways are considered. In keeping with BLM policy, proposed treatments will be modified to avoid adverse effects on significant cultural resources and lifeways. Alternative 5 has the lowest probability of impact because this alternative has the fewest acres treated with manual and mechanical methods. Alternative 3 could have the greatest impacts because more mechanical treatments would be used than under any other alternative.

Recreation and Visual Resources

All program alternatives would result in short-term scenic degradation. Recreation areas infested with noxious weeds and poisonous plants would benefit by reducing potential visitor exposure to harmful vegetation species. Alternative 3 could have the greatest adverse impacts because without herbicides some noxious weeds would be difficult to control. Alternative 1 could have the most beneficial impact overall because it would enable use of the best treatment method for a particular site.

Livestock

Livestock should not be directly affected by any of the treatment methods, and the adverse impacts on livestock forage would be short term. Alternative 1 would have the most beneficial impacts for livestock because forage production could be maintained or improved, and toxic plants could be controlled by the best suited methods. Without using herbicides (Alternative 3), noxious weeds and poisonous plants would be more difficult to control and therefore could adversely affect livestock.

Wild Horses and Burros

Wild horses and burros should not be adversely affected under any of the alternatives. In fact, they should benefit from increased forage quantity and quality, receiving the most benefit from Alternative 1.

Special Status Species

The possible impacts to special status plant and animal species are potentially the same as those discussed under vegetation and fish and wildlife. However, analyses completed before any site is treated would identify any special status species at the site, and appropriate measures would be taken to protect that species. Therefore, the impacts from treatment methods and alternatives to special status species should be negligible. In addition, treatments such as removal of exotic species should enhance habitats for special status species.

Wilderness and Special Areas

Wilderness and special areas are not likely to be adversely affected by the treatment methods under any of the alternatives. Undesirable vegetation in wilderness areas and wilderness study areas may be controlled, allowing native plants in the natural ecosystem to better compete. Site-specific impacts to special areas will be addressed further in district or resource area analyses that precede vegetation treatment actions.

Human Health and Safety

Manual methods of vegetation treatment should not affect members of the public because they would not handle any of the equipment involved. Workers using hand tools could receive minor injuries or major injuries from using power tools.

Mechanical methods should not affect members of the public. Workers would be at risk of the same types of injuries that agricultural or construction workers might incur when using tractors and other heavy equipment.

Neither members of the public nor workers would be affected by biological methods of vegetation treatment.

Sensitive members of the public and some workers may experience minor ill effects, such as eye and lung irritation, for the smoke of prescribed fires. In addition, workers may suffer burns when igniting or managing prescribed fires, although BLM guidance policies and required protective clothing minimize this risk.

None of the proposed herbicide uses pose a health risk to members of the public from typical exposures in any program area. Exposures to workers involved in herbicide application were conservatively calculated to avoid underestimation. Workers may be at risk from some herbicides if they receive these exposures. However, mitigation, such as protective clothing and strict adherence to BLM herbicide application guidance, should reduce the actual exposures workers receive to levels that do not pose any significant risks. Some workers on rangeland are at risk of systemic effects from atrazine,

2,4-D, dalapon, dicamba, tebuthiuron, triclopyr, and diesel oil; reproductive effects from atrazine, 2,4-D, dicamba, glyphosate, and tebuthiuron; and a theoretical cancer risk from atrazine and 2,4-D.

Under typical conditions of public-domain forest land herbicide applications, members of the public are not at risk from systemic effects. No adverse reproductive effects are expected from any herbicide use. Workers in this scenario are at risk of systemic effects from using 2,4-D and triclopyr; reproductive effects from atrazine and tebuthiuron; and increased cancer risks from amitrole, atrazine, 2,4-D, and simazine.

Under typical conditions for oil and gas treatment sites, members of the public are not at risk from systemic, reproductive, or carcinogenic effects. Some workers on these sites are at systemic risk from atrazine, bromacil, 2,4-D, diuron, simazine, and triclopyr; reproductive risk from atrazine, diuron, simazine, and tebuthiuron; and cancer risk from atrazine, bromacil, 2,4-D, and simazine.

On rights-of-way in the typical case, members of the public are not at risk from systemic effects. Some workers are at risk of systemic effects from atrazine, bromacil, 2,4-D, diuron, mefluidide, metsulfuron methyl, simazine, and triclopyr; reproductive effects from atrazine, diuron, simazine, and tebuthiuron; and carcinogenic effects from atrazine, bromacil, 2,4-D, and simazine.

Members of the public would have no significant systemic, reproductive, or carcinogenic risks from herbicide treatments of recreation and cultural sites. Under typical conditions, some workers may be at risk of systemic effects from using atrazine, 2,4-D, and triclopyr; reproductive effects from atrazine and tebuthiuron; and a theoretical cancer probability from atrazine, 2,4-D, and simazine.

The risks estimated in the risk assessment for this EIS are those that would be expected under Alternative 1. Alternative 2 would limit the risk of public exposure to the herbicides, as well as eliminate risks to workers on an aerial application team. Alternative 3 would eliminate all herbicide risks to members of the public and workers. Alternative 4 would eliminate risks from smoke inhalation and potential fire injuries to workers. Alternative 5 would reduce the risks from all methods, as compared to Alternative 1 on a population-wide basis, because fewer acres would be treated.

Social and Economic Resources

Vegetation treatment costs would vary by alternative. Employment opportunities would have a minimal increase, regardless of the treatment program implemented. Untreated acreage damages public and private resources, causing economic losses and decreased aesthetic value. Alternative 1 has the lowest treatment cost per acre than Alternatives 2, 3, or 4. Alternative 5 has the lowest cost per acre of any alternative, but it also offers no new employment opportunities. Alternative 3 offers the most employment opportunities and no use of herbicides is more socially desirable to some populations.

MEASURES TO MINIMIZE IMPACTS

BLM will employ the standard operating procedures and mitigation described in Chapter 1 to minimize adverse impacts on the environment in the EIS area. BLM manuals and handbooks provide standards and provisions for resource improvements and treatments. Mitigation was developed based on the analysis in this EIS.

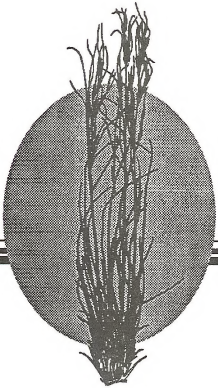
The standard procedure for vegetation treatment on a particular site begins with a review of objectives stated in the land use plan covering that site. A site field survey is conducted to determine the presence and proximity of resources that may be at risk from the treatments, including human habitations, aquatic resources, special status species, and cultural resources.

The kinds of mitigation, both project design features and special mitigation, concerning herbicide use, in particular, that would be used to limit risk to these resources may include suspending aerial herbicide applications whenever weather conditions may cause offsite drift or runoff, limiting use of herbicides that pose human health risks, and providing buffer zones along riparian areas.

Prescribed fire would not be used when fuel moisture conditions are too low or when the burn might become too hot from a structure or resource that is too close to the site to ensure safety. Prescribed burning activities must comply with BLM Manual requirements to minimize air quality impacts from smoke. Under all Alternatives, Federal, state and local air quality regulations would not be violated.

Chapter 1

Proposed Action and Alternatives



CHAPTER 1

PROPOSED ACTION AND ALTERNATIVES

INTRODUCTION

The Bureau of Land Management (BLM), U.S. Department of the Interior (USDI), proposes treatment of vegetation on public lands in 13 Western States. Some of the treatment methods have the potential for significant impacts on the environment. This final environmental impact statement (FEIS) analyzes potential impacts on the natural and human environment that may occur as a result of the proposed action and alternatives.

This FEIS is presented in five chapters and fourteen appendixes (Figure 1-1). This chapter first identifies the purpose and need to which BLM is responding in proposing vegetation treatment, including the legal authorities under which the action is being proposed, and then describes BLM's requirement to prepare this programmatic document. This is followed by summaries of the proposed treatment program and alternative programs, the treatment methods that would be used in each program, and the environmental impacts. The implementation of this final EIS and the relationship of this vegetation treatment action to other Federal and State actions and to the private sector are then described. The final section discusses the limitations of this document.

Acreage figures shown are for analysis purposes only. There are various factors such as funding, available manpower, and need for treatment that will affect the number of acres treated.

The BLM will not exceed the acres projected in Tables 1-1 through 1-6 on an average annual basis over the life of the EIS. Several factors may cause a reduction or increases in acreage in any given year, such as available funds, other workloads, revised land use planning, Threatened and Endangered species conflicts, cultural and visual resources and management concerns.

Chapter 2 describes the physical and biological characteristics of areas in the 13 Western States that could be affected by a vegetation treatment program. Chapter 3 presents the impacts on these physical and biological characteristics that are likely to occur with the implementation of any of the treatment alternatives. Public participation in the development of this final EIS is described in Chapter 4. Chapter 5 lists the preparers and reviewers.

The first six appendixes provide supporting and additional background information: a glossary (Appendix A), comments received during public scoping (Appendix B); description of the nonchemical treatment methods (Appendix C); detailed results of the prescribed burning (Appendix D); herbicide risk assessments (Appendix E); and the fire ecology of western plants (Appendix F). Appendixes G, H, and I list the common and scientific names of plant and animal species, special status species, and target species, respectively. References for BLM program direction concerning the use of renewable resource improvements are included as Appendix J. Each person, organization, or agency that provided written comments are listed in Appendix K. Appendix L is the distribution list for the draft EIS. Appendix M is a list of herbicide formulations, and copies of the Federal Noxious Weed Control Laws are shown in Appendix N.

PURPOSE AND NEED FOR ACTION

Program Objectives

A key objective of the Vegetative Treatment Program is to increase soil stability, improve quality and sustained yield of water, reduce the spread of noxious weeds, and increase desired plant species to meet objectives of the land use plans (LUPs). Vegetative treatments will be done with the utmost concern for human health and safety. Vegetative treatment needs arise for many different conditions and purposes.

A prescription for the management and use of an area (such as the provision of habitat for wildlife and livestock use) may require that certain desired vegetation attributes that do not currently exist be developed. For example, a vegetation community with a sagebrush canopy cover exceeding 50 percent may not be desirable because of suppression of herbaceous understory species. The same community with a 10- to 15-percent canopy cover may be highly desirable because it has ample herbaceous understory production and still provides nesting cover for song birds and sage grouse, as well as winter forage for herbivores.

The proposed vegetation treatment program is needed to respond to many different plant control requirements, including suppressing plants that are toxic to humans and animals, enhancing visibility, maintaining passages for transportation, facilitating drainage, reducing fuel for wildfires, and controlling

Additional supporting and background information is presented in appendices:

A. Glossary
B. Scoping Summary
C. Nonchemical Vegetation Treatment Methods
D. Risks from Prescribed Burning
E. Herbicide Risk Assessment
F. Fire Ecology of Western Plant Species
G. Species Scientific Names
H. Special Status Species
I. Target Plant Species
J. BLM Manual References for Renewable Resource Improvements
K. List of Commenters
L. Distribution of The Draft EIS
M. Herbicide Formulations
N. Federal Noxious Weed Control Laws

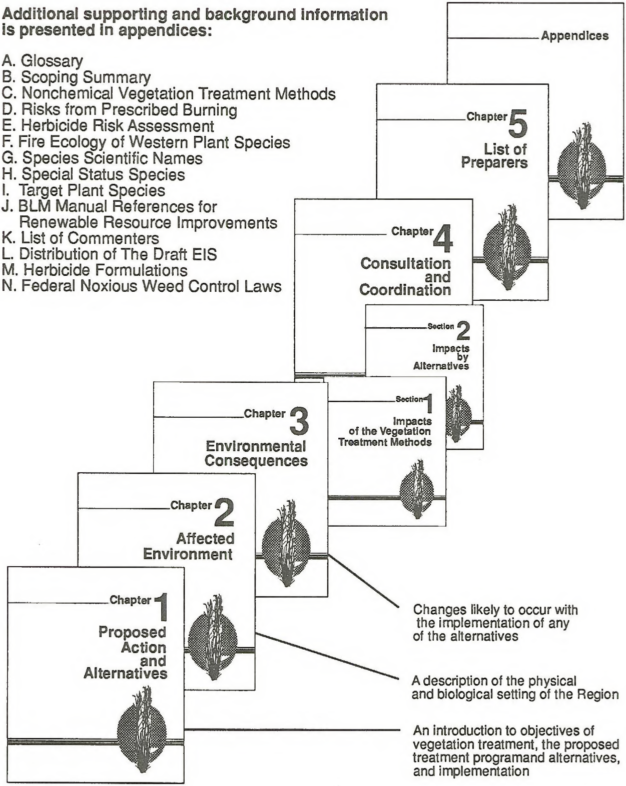


Figure 1-1
How This EIS is Organized

Table 1-1

Estimated Average Annual Acres Treated by Program Alternative and Treatment Method

Figures include acres to be treated during the next 10 - 15 years (pending availability of funds) on all BLM Lands including Rangelands, Rights-of-way. Oil and Gas leases, Public Domain Forest Lands and developed Recreation Lands.

Treatment Method	Proposed Action: Alternative 1	No Aerial Application of Herbicides: Alternative 2	No Use of Herbicides Alternative 3	No Prescribed Burning: Alternative 4	No Action: Alternative 5
Manual					
Cutting	10,310	10,310	10,010	9,910	8,745
Pulling	605	530	480	430	475
Scalping	2,575	2,750	2,800	2,750	2,930
Mulching	580	580	580	580	620
Total Manual	**14,070**	**14,170**	**13,870**	**13,670**	**12,770**
Mechanical					
Chaining	13,750	22,350	22,950	19,650	10,890
Tilling	27,200	30,100	31,700	30,800	13,385
Mowing	7,435	8,735	9,235	9,035	6,630
Cutting	1,800	1,950	2,150	2,050	1,635
Roller Chopping	3,300	3,300	3,400	3,300	0
Bulldozing	400	500	500	100	400
Grubbing	500	500	500	500	160
Blading	800	800	800	800	810
Drilling	2,930	2,930	2,980	2,930	8,035
Total Mechanical	**58,115**	**71,165**	**74,215**	**69,165**	**41,945**
Biological					
Grazing	56,225	56,225	56,225	56,225	53,925
Insects	3,750	3,650	3,750	3,750	3,710
Pathogens	200	200	200	200	0
Total Biological	**60,175**	**60,075**	**60,175**	**60,175**	**57,635**
Total Prescribed Burning[1]	**97,765**	**132,290**	**136,390**	**0**	**92,680**
Chemical					
Aerial					
Helicopter	55,975	0	0	94,740	1,395
Fixed-Wing Aircraft	58,700	0	0	46,000	24,370
Ground					
Vehicle	21,045	38,033	0	28,075	9,615
Hand	5,795	7,135	0	6,545	2,095
Total Chemical	**141,515**	**45,168**	**0**	**175,360**	**37,475**
GRAND TOTAL	**371,640**	**322,868**	**284,650**	**318,370**	**242,505**

[1] An estimated 25% of the prescribed burn acreage is a follow-up treatment to chaining or spraying. Thus, total treated acreage would be reduced accordingly.

Table 1-2
Estimated Average Annual Acres Treated by State Alternative 1

	Arizona	Colorado	Idaho	Montana, North Dakota & South Dakota	Nevada	New Mexico & Oklahoma	Oregon & Washington	Utah	Wyoming	TOTAL
Manual										
Cutting	50	1,100	1,400	320	6,505	100	65	600	170	10,310
Pulling	0	0	175	100	55	100	175	0	0	605
Scalping	0	0	125	200	50	100	2,000	0	100	2,575
Mulching	0	0	0	200	0	0	0	0	380	580
Total Manual	**50**	**1,100**	**1,700**	**820**	**6,610**	**300**	**2,240**	**600**	**650**	**14,070**
Mechanical										
Chaining	2,000	100	5,400	300	500	300	100	4,900	150	13,750
Tilling	1,600	1,300	15,550	2,790	1,200	0	360	3,700	700	27,200
Mowing	600	0	1,100	1,400	300	100	585	2,600	750	7,435
Cutting	50	1,000	250	180	0	0	340	0	0	1,820
Roller Chopping	0	0	3,200	0	0	0	0	100	0	3,300
Bulldozing	0	300	0	0	100	0	0	0	0	400
Grubbing	0	0	0	0	0	500	0	0	0	500
Blading	0	0	0	0	0	0	0	0	800	800
Drilling Seed	0	1,500	0	1,360	0	0	0	50	0	2,910
Total Mechanical	**4,250**	**4,200**	**25,500**	**6,030**	**2,100**	**900**	**1,385**	**11,350**	**2,400**	**58,115**
Biological										
Grazing	0	100	2,300	48,400	0	0	5,425	0	0	56,225
Insects	0	100	0	3,100	0	0	300	200	50	3,750
Pathogens	0	0	0	200	0	0	0	0	0	200
Total Biological	**0**	**200**	**2,300**	**51,700**	**0**	**0**	**5,725**	**200**	**50**	**60,175**
Total Prescribed Burning	**9,300**	**8,150**	**34,075**	**1,400**	**2,000**	**6,100**	**15,240**	**6,200**	**15,300**	**97,765**
Chemical										
Aerial										
Helicopter	5,300	200	3,225	1,400	10,000	1,000	32,550	2,000	300	55,975
Fixed Wing	0	1,000	19,700	0	3,000	31,000	0	3,300	700	58,700
Ground										
Vehicle	2,100	600	1,340	2,205	500	1,400	3,800	4,400	4,700	21,045
Hand	800	500	380	905	200	400	1,010	400	1,200	5,795
Total Chemical	**8,200**	**2,300**	**24,645**	**4,510**	**13,700**	**33,800**	**37,360**	**10,100**	**6,900**	**141,515**
Treatment Total	**21,800**	**15,950**	**88,220**	**64,460**	**24,410**	**41,100**	**61,950**	**28,450**	**25,300**	**371,640**
TOTAL BLM ADMINISTERED LANDS[1]	**12,428,584**	**8,276,890**	**11,867,773**	**8,417,283**	**47,062,636**	**12,872,729**	**13,745,487**	**22,141,908**	**18,404,034**	**156,117,324**

[1] Figures were taken from U.S. Department of the Interior, Bureau of Land Management, Public Land Statistics, 1989 edition; Eastern Oregon and Washington figures are only that area addressed in this EIS.

Table 1-3

Estimated Average Annual Acres Treated by State
Alternative 2

	Arizona	Colorado	Idaho	Montana, North Dakota & South Dakota	Nevada	New Mexico & Oklahoma	Oregon & Washington	Utah	Wyoming	TOTAL
Manual										
Cutting	50	1,100	1,400	320	6,505	100	65	600	170	10,310
Pulling	0	0	0	100	55	100	175	100	0	530
Scalping	0	0	300	200	50	100	2,000	0	100	2,750
Mulching	0	0	0	200	0	0	0	0	380	580
Total Manual	**50**	**1,100**	**1,700**	**820**	**6,610**	**300**	**2,240**	**700**	**650**	**14,170**
Mechanical										
Chaining	2,000	100	6,500	300	1,000	4,700	2,700	4,900	150	22,350
Tilling	1,600	1,400	15,700	2,790	2,300	0	1,910	3,700	700	30,100
Mowing	600	0	1,300	1,400	300	100	1,135	3,150	750	8,735
Cutting	50	1,000	400	160	0	0	340	0	0	1,950
Roller Chopping	0	0	3,200	0	0	0	0	100	0	3,300
Bulldozing	0	400	0	0	100	0	0	0	0	500
Grubbing	0	0	0	0	0	500	0	0	0	500
Blading	0	0	0	0	0	0	0	0	800	800
Drilling Seed	0	1,500	0	1,380	0	0	0	50	0	2,930
Total Mechanical	**4,250**	**4,400**	**27,100**	**6,030**	**3,700**	**5,300**	**6,085**	**11,900**	**2,400**	**71,165**
Biological										
Grazing	0	100	2,300	48,400	0	0	5,425	0	0	56,225
Insects	0	100	0	3,100	0	0	300	100	50	3,650
Pathogens	0	0	0	200	0	0	0	0	0	200
Total Biological	**0**	**200**	**2,300**	**51,700**	**0**	**0**	**5,725**	**100**	**50**	**60,075**
Total Prescribed Burning	**12,000**	**8,150**	**37,000**	**1,400**	**3,000**	**8,600**	**38,740**	**8,000**	**15,400**	**132,290**
Chemical										
Aerial										
Helicopter	0	0	0	0	0	0	0	0	0	0
Fixed-Wing	0	0	0	0	0	0	0	0	0	0
Ground										
Vehicle	4,300	700	12,650	2,675	3,000	3,000	5,500	1,508	4,700	38,033
Hand	800	600	1,220	1,105	200	400	1,010	600	1,200	7,135
Total Chemical	**5,100**	**1,300**	**13,870**	**3,780**	**3,200**	**3,400**	**6,510**	**2,108**	**5,900**	**45,168**
Treatment Total	**21,400**	**15,150**	**81,970**	**63,730**	**16,510**	**17,600**	**59,300**	**22,808**	**24,400**	**322,868**
TOTAL BLM ADMINISTERED LANDS[1]	**12,428,584**	**8,276,890**	**11,867,773**	**8,417,283**	**47,062,636**	**12,872,729**	**13,745,487**	**22,141,908**	**18,404,034**	**156,117,324**

[1] Figures were taken from U.S. Department of the Interior, Bureau of Land Management, Public Land Statistics, 1989 edition; Eastern Oregon and Washington figures are only that area addressed in this EIS.

Table 1-4

Estimated Average Annual Acres Treated by State
Alternative 3

	Arizona	Colorado	Idaho	Montana, North Dakota & South Dakota	Nevada	New Mexico & Oklahoma	Oregon & Washington	Utah	Wyoming	TOTAL
Manual										
Cutting	50	1,100	1,400	320	6,505	200	65	200	170	10,010
Pulling	0	0	0	100	105	100	175	0	0	480
Scalping	0	0	300	200	100	100	2,000	0	100	2,800
Mulching	0	0	0	200	0	0	0	0	380	580
Total Manual	**50**	**1,100**	**1,700**	**820**	**6,710**	**400**	**2,240**	**200**	**650**	**13,870**
Mechanical										
Chaining	2,000	200	6,500	300	1,000	4,700	3,200	4,900	150	22,950
Tilling	2,700	1,400	15,700	2,790	2,500	0	2,210	3,700	700	31,700
Mowing	800	0	1,300	1,400	300	400	1,135	3,150	750	9,235
Cutting	50	1,000	400	160	0	200	340	0	0	2,150
Roller Chopping	0	0	3,200	0	0	0	0	200	0	3,400
Bulldozing	0	400	0	0	100	0	0	0	0	500
Grubbing	0	0	0	0	0	500	0	0	0	500
Blading	0	0	0	0	0	0	0	0	800	800
Drilling Seed	0	1,500	0	1,380	0	0	0	100	0	2,980
Total Mechanical	**5,550**	**4,500**	**27,100**	**6,030**	**3,900**	**5,800**	**6,885**	**12,050**	**2,400**	**74,215**
Biological										
Grazing	0	100	2,300	48,400	0	0	5,425	0	0	56,225
Insects	0	100	0	3,100	0	0	300	200	50	3,750
Pathogens	0	0	0	200	0	0	0	0	0	200
Total Biological	**0**	**200**	**2,300**	**51,700**	**0**	**0**	**5,725**	**200**	**50**	**60,175**
Total Prescribed Burning	**12,400**	**8,150**	**38,000**	**1,400**	**4,500**	**8,600**	**39,740**	**8,000**	**15,600**	**136,390**
Chemical										
Aerial										
Helicopter	0	0	0	0	0	0	0	0	0	0
Fixed Wing	0	0	0	0	0	0	0	0	0	0
Ground										
Vehicle	0	0	0	0	0	0	0	0	0	0
Hand	0	0	0	0	0	0	0	0	0	0
Total Chemical	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Treatment Total	**18,000**	**13,950**	**69,100**	**59,950**	**15,110**	**14,800**	**54,590**	**20,450**	**18,700**	**284,650**
TOTAL BLM ADMINISTERED LANDS[1]	**12,428,584**	**8,276,890**	**11,867,773**	**8,417,283**	**47,062,636**	**12,872,729**	**13,745,487**	**22,141,908**	**18,404,034**	**156,117,324**

[1] Figures were taken from U.S. Department of the Interior, Bureau of Land Management, Public Land Statistics, 1989 edition; Eastern Oregon and Washington figures are only that area addressed in this EIS.

Table 1-5

Estimated Average Annual Acres Treated by State
Alternative 4

	Arizona	Colorado	Idaho	Montana, North Dakota & South Dakota	Nevada	New Mexico & Oklahoma	Oregon & Washington	Utah	Wyoming	TOTAL
Manual										
Cutting	50	1,100	1,400	320	6,505	100	65	200	170	9,910
Pulling	0	0	0	100	55	100	175	0	0	430
Scalping	0	0	300	200	50	100	2,000	0	100	2,750
Mulching	0	0	0	200	0	0	0	0	380	580
Total Manual	**50**	**1,100**	**1,700**	**820**	**6,610**	**300**	**2,240**	**200**	**650**	**13,670**
Mechanical										
Chaining	2,100	200	5,000	300	1,000	300	3,200	7,400	150	19,650
Tilling	2,200	1,400	15,600	2,790	1,300	0	2,210	4,600	700	30,800
Mowing	500	0	1,300	1,400	300	100	1,135	3,550	750	9,035
Cutting	50	1,000	400	160	0	100	340	0	0	2,050
Roller Chopping	0	0	3,200	0	0	0	0	100	0	3,300
Bulldozing	0	0	0	0	100	0	0	0	0	100
Grubbing	0	0	0	0	0	500	0	0	0	500
Blading	0	0	0	0	0	0	0	0	800	800
Drilling Seed	0	1,500	0	1,380	0	0	0	50	0	2,930
Total Mechanical	**4,850**	**4,100**	**25,500**	**6,030**	**2,700**	**1,000**	**6,885**	**15,700**	**2,400**	**69,165**
Biological										
Grazing	0	100	2,300	48,400	0	0	5,425	0	0	56,225
Insects	0	100	0	3,100	0	0	300	200	50	3,750
Pathogens	0	0	0	200	0	0	0	0	0	200
Total Biological	**0**	**200**	**2,300**	**51,700**	**0**	**0**	**5,725**	**200**	**50**	**60,175**
Total Prescribed Burning	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Chemical										
Aerial										
Helicopter	14,000	200	15,300	1,400	11,000	1,000	48,340	2,500	1,000	94,740
Fixed-Wing	0	1,000	0	0	3,000	33,000	0	4,000	5,000	46,000
Ground										
Vehicle	2,100	700	8,200	2,175	500	1,400	5,500	4,400	3,100	28,075
Hand	800	300	1,220	915	300	400	1,010	500	1,100	6,545
Total Chemical	**16,900**	**2,200**	**24,720**	**4,490**	**14,800**	**35,800**	**54,850**	**11,400**	**10,200**	**175,360**
Treatment Total	**21,800**	**7,600**	**54,220**	**63,040**	**24,110**	**37,100**	**69,700**	**27,500**	**13,300**	**318,370**
TOTAL BLM ADMINISTERED LANDS[1]	**12,428,584**	**8,276,890**	**11,867,773**	**8,417,283**	**47,062,636**	**12,872,729**	**13,745,487**	**22,141,908**	**18,404,034**	**156,117,324**

[1] Figures were taken from U.S. Department of the Interior, Bureau of Land Management, Public Land Statistics, 1989 edition; Eastern Oregon and Washington figures are only that area addressed in this EIS.

Table 1-6

Estimated Average Annual Acres Treated by State Alternative 5

	Arizona	Colorado	Idaho	Montana, North Dakota & South Dakota	Nevada	New Mexico & Oklahoma	Oregon & Washington	Utah	Wyoming	TOTAL
Manual										
Cutting	50	1,025	10	320	6,505	50	65	550	170	8,745
Pulling	0	0	0	100	55	100	175	45	0	475
Scalping	0	10	480	190	50	100	2,000	0	100	2,930
Mulching	0	40	0	200	0	0	0	0	380	620
Total Manual	**50**	**1,075**	**490**	**810**	**6,610**	**250**	**2,240**	**595**	**650**	**12,770**
Mechanical										
Chaining	2,000	500	0	150	600	425	3,200	3,865	150	10,890
Tilling	1,600	0	2,400	2,430	1,200	0	2,210	2,845	700	13,385
Mowing	600	0	100	1,210	300	85	535	3,050	750	6,630
Cutting	50	1,000	160	85	0	0	340	0	0	1,635
Roller Chopping	0	0	0	0	0	0	0	0	0	0
Bulldozing	0	200	100	0	100	0	0	0	0	400
Grubbing	0	0	160	0	0	0	0	0	0	160
Blading	0	0	10	0	0	0	0	0	800	810
Drilling Seed	0	1,500	4,510	1,380	600	0	0	45	0	8,035
Total Mechanical	**4,250**	**3,200**	**7,440**	**5,255**	**2,800**	**510**	**6,285**	**9,805**	**2,400**	**41,945**
Biological										
Grazing	0	100	0	48,400	0	0	5,425	0	0	53,925
Insects	0	100	110	3,100	0	0	300	100	0	3,710
Pathogens	0	0	0	0	0	0	0	0	0	0
Total Biological	**0**	**200**	**110**	**51,500**	**0**	**0**	**5,725**	**100**	**0**	**57,635**
Total Prescribed Burning	**9,300**	**8,470**	**8,650**	**350**	**3,500**	**1,500**	**39,740**	**5,870**	**15,300**	**92,680**
Chemical										
Aerial										
Helicopter	0	0	0	0	0	0	0	1,095	300	1,395
Fixed Wing	0	0	0	0	0	21,000	0	2,670	700	24,370
Ground										
Vehicle	0	100	0	675	0	900	0	3,240	4,700	9,615
Hand	0	100	0	195	0	100	0	500	1,200	2,095
Total Chemical	**0**	**200**	**0**	**870**	**0**	**22,000**	**0**	**7,505**	**6,900**	**37,475**
Treatment Total	**13,600**	**13,145**	**16,690**	**58,785**	**12,910**	**24,260**	**53,990**	**23,875**	**25,250**	**242,505**
TOTAL BLM ADMINISTERED LANDS[1]	**12,428,584**	**8,276,890**	**11,867,773**	**8,417,283**	**47,062,636**	**12,872,729**	**13,745,487**	**22,141,908**	**18,404,034**	**156,117,324**

[1] Figures were taken from U.S. Department of the Interior, Bureau of Land Management, Public Land Statistics, 1989 edition; Eastern Oregon and Washington figures are only that area addressed in this EIS.

the expansion of exotic species, which includes noxious weeds, that may invade adjacent agriculture or pasture lands. (Other specific needs are addressed in the Program Areas section.)

Vegetation treatments which benefit livestock forage most always generate additional benefits such as increased big and small game production, increased hunter days, reduced soil erosion, and improved water quality such as reduced salinity. It is BLM's policy to develop cost effective range improvements which will result in a favorable return on the funds invested. It is policy to consider all costs and all benefits to the extent they can be quantified.

BLM is proposing a holistic approach based on the vegetation management needs as identified in site specific land use plans. The overall productivity of public lands can be improved for wildlife, watershed, recreation, and livestock forage through the proper management and manipulation of vegetation.

Many natural ecosystems have been altered as a result of man's presence. Introduction of non-native species such as noxious weeds and suppression of naturally occurring fires have also altered many ecosystems along with heavy grazing by both livestock and wildlife. Due to these influences holistic management must include land treatment in order to meet land use plan objectives.

BLM proposes to implement a vegetation treatment program on 372,000 acres annually in Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, North Dakota, Oklahoma, eastern Oregon, South Dakota, Utah, Washington, and Wyoming (Figure 1-2). The impacts of BLM's program to manage vegetation in California and western Oregon were addressed in separate EIS documents (BLM 1989a, BLM 1989b) and therefore are not analyzed here.

The main benefit of noxious weed control on public lands is not only the prevention of economic losses related to activities on these lands, but the prevention of economic losses sustained on nearby private lands that result when uncontrolled weed infestations on public lands spread to infest and reinfest the private lands.

Because of the detrimental effects of some noxious weeds on animals and humans, no control in some instances encourages hazard and economic losses as is emphasized in the Federal Noxious Weed Act (PL 93-629), which states that distribution of noxious weeds "... allows the growth and spread of such weeds which cause disease or have other adverse effects on man or his environment, therefore, is detrimental to the agriculture and commerce of the United States and to the public health." According to the National Academy of Sciences (1968), an estimated 75,000 people suffer poisoning by plants annually.

Chemical and biological treatment for the control of noxious weeds can be effective tools for treating non-grazing lands. Some of the most serious noxious weed problems on public lands are found in areas where no grazing occurs. These include highway rights-of-way, railroads, recreation sites, riparian exclosures, oil and gas drill sites and related transmission facilities, and any area where surface disturbing activities have occurred, such as wildfires.

Noxious weeds have become established and are rapidly spreading on both public and private rangeland, woodlands and farm land (Forcella and Harvey, 1981; Messersmith and Lym, 1983; Bucher, 1984; French and Lacey, 1983). As a result, crop yields are being reduced, rangeland in good ecological condition is being invaded, and wildlife habitat is being reduced (Chase, 1985; Bucher, 1984; Kelsey, 1984; Morris and Bedunah, 1984; Penhallegon, 1983). Economic loss from noxious weeds is considerable and costs millions of dollars annually in each state in the EIS area, posing a serious menace to the public welfare and the state's economic stability (Kelsey, 1984; Jenson, 1984; Bucher, 1984; Chase, 1985; Lewiston Morning Tribune, 1980; Baker, 1983; Nielson, 1978; Thompson and others, 1990). Noxious weeds cannot be adequately controlled unless federal, state, county and private interests work together in controlling weeds using effective and efficient means (Lacey and Fay, 1984; French, 1984; Hahnkamp and Pence, 1984; Ali, 1984).

Many noxious weeds are spread by recreational vehicles, geophysical equipment, campers, backpackers, hunters, big game and non-game species, as well as by livestock. With more and more use of the public lands, noxious weeds will spread into many areas including wilderness. Some species, such as the thistles and knapweeds, will cause these areas to become highly undesirable due to the weed problems which occur. Also, many of the introduced species of the noxious weeds are a very significant threat to agricultural croplands, as a result of their competitive nature.

The proposed program, an expansion of the existing Integrated Pest Management (IPM) program, would allow the use of manual, mechanical, biological, prescribed burning, or chemical treatments on more acres than are now being treated. IPM is the selection, integration, and implementation of treatment methods based on predicted ecologic, sociologic, and economic effects (BLM 1981a). Three of the alternatives to the proposed program restrict or eliminate the use of one of the treatment methods: no aerial application of herbicides, no use of herbicides, and no prescribed burning. Continuation of the existing management program is the final alternative considered in this document.

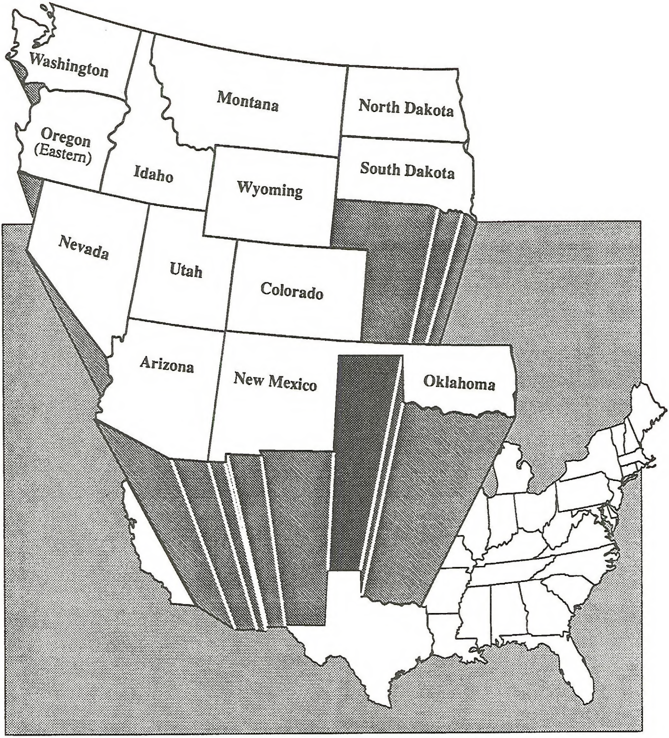


Figure 1-2
States included in the Vegetation Treatment Program

Concerns about using prescribed burning were raised during public scoping (see Public Involvement Section, and Appendix B); consequently, BLM added a no-prescribed-burning program alternative. Analysis of a no action alternative, a continuation of the current program, is required under 40 CFR Part 1502.14(d). No change from current management is considered to be the appropriate no action alternative when ongoing programs initiated under existing legislation and regulations will continue (46 CFR 18027). No aerial application of herbicides and no use of herbicides have been assessed because of continuing concerns about possible health effects and environmental damage from the use of herbicides.

Legal Mandates for the Program

BLM is required to manage public lands and their resources by the Federal Land Policy and Management Act of 1976 (43 U.S.C. 1700 et seq.). This law established policy for BLM administration of public lands under its jurisdiction. The Taylor Grazing Act of 1934 (43 U.S.C. 315 et seq.) introduced Federal protection and management of public lands by regulating grazing on public lands. The Public Rangelands Improvement Act of 1978 (43 U.S.C. 1901 et seq.) required BLM to manage, maintain, and improve the public lands suitable for livestock grazing so that they become as productive as feasible. Two Federal laws direct weed control on Federal lands: the Federal Noxious Weed Act of 1974 (7 U.S.C. 2801-2813), as amended by Sec. 15, Management of Undesirable Plants on Federal Lands, 1990, and the Carson-Foley Act of 1968 (PL 90-583).

State and county laws commonly place responsibility for noxious weed control on Federal land with the Federal Government. BLM will comply with the individual States' noxious weed management acts.

NEPA Requirements of the Program

Federal agencies are required by the National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. 4321 et seq.), as amended, to prepare an EIS if a proposed action has a potential for significant environmental impacts (Figure 1-3). In accordance with NEPA, this final EIS identifies impacts of the proposed vegetation treatment program and four alternative programs. It may be used as a broad, comprehensive background source on which any necessary subsequent environmental analyses can be tiered, in accordance with the Council on Environmental Quality's (CEQ) procedures for implementing NEPA (40 CFR 1500-1508). Tiering eliminates repetitive discussions of the same issues and allows consideration of the actual issues that are relevant for decision at each level of environmental review.

The intent of this final EIS is to comply with NEPA and the courts by assessing the program impacts of treating undesired vegetation species; the necessity for treatment would be determined by BLM's land-use plans. This final EIS will also be used to facilitate analysis of the treatment alternatives in the land-use planning process and implementation of BLM's land-use decisions. The treatment methods assessed in this final EIS would be available for use at the local level to accomplish local land-use plan objectives.

Future environmental analyses of vegetation treatment will be conducted at the project level and will focus on resources that are unique to specific sites, as necessary. BLM field offices will be responsible for preparing site-specific environmental assessments as needed.

Several recent EISs are relevant to the issues addressed in this final EIS and have been used for reference: Northwest Area Noxious Weed final EIS and Supplement (BLM 1985a, 1987a), Western Oregon Management of Competing Vegetation final EIS (BLM 1989b), California Vegetation Management final EIS (BLM 1989a), Vegetation Management in the Coastal Plain/Piedmont final EIS (USDA 1989), Pacific Northwest Management of Competing and Unwanted Vegetation final EIS (USDA 1988), and Eradication of Cannabis on Federal Lands in the Continental United States final EIS (DEA 1985). This programmatic EIS is prepared to address NEPA compliance for those States not previously covered in EISs for vegetation treatment programs by BLM.

The CEQ Regulations for Implementing the Procedural Provisions of NEPA (40 CFR Parts 1500-1508) and USDI manuals (USDI n.d., BLM 1988a) provide additional guidance for NEPA compliance and for the content and format of this final EIS.

Public Involvement

Public involvement is recognized as an essential element in the development of an EIS and achieving a successful program for the management of public lands and natural resources. When the decision was made to complete this vegetation treatment EIS, a public participation and coordination plan was developed. Public participation continues after the document is complete and used for site-specific and project-level planning.

Following BLM's decision to proceed with this programmatic vegetation treatment EIS, a Notice of Intent was issued on July 17, 1988. The scoping period in most States ended August 19, 1988; scoping

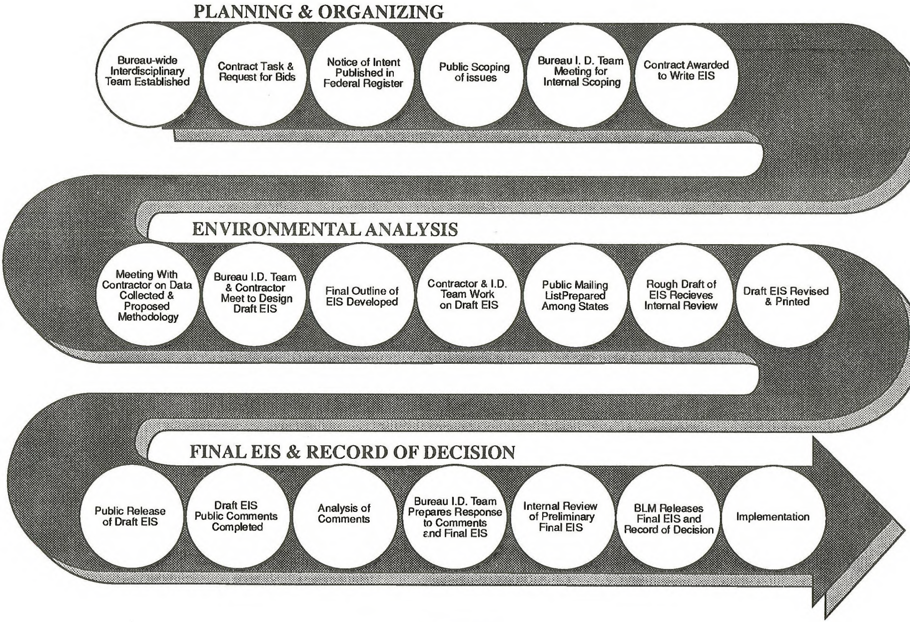


Figure 1-3
The Process

in Colorado, Montana, North Dakota, and South Dakota ended September 30, 1988.

Four areas of concern were identified through the scoping process: (1) the safety and accuracy of aerially applied herbicides; (2) any use of herbicides, regardless of the application method; (3) the potential impacts brought about by the alteration of natural ecological systems, regardless of the vegetation treatment method; and (4) concerns about prescribed burning. (Scoping is further discussed in Appendix B.)

Program Areas

Rangeland, public domain forest land, oil and gas production facility sites, rights-of-way, and recreation and cultural area treatments would be included in the program to treat a number of noxious weeds and undesirable plant species (Appendix I). These vegetation treatments would be made to facilitate sound resource management practices. This FEIS addresses the impacts of proposed noxious weed treatments for the first time in Arizona, Colorado, Nevada, New Mexico, North Dakota, Oklahoma, South Dakota, and Utah; treatment of noxious weeds in the other five States was analyzed in an earlier EIS (BLM 1985a). Vegetation treatments for this EIS analysis are described in the following sections.

Rangeland Treatments

Rangeland treatments would be made to achieve desired range conditions, increase forage production for livestock and wildlife, create stratified age structure dynamics in brushlands and chaparral for wildlife habitat improvement and fuel hazard reduction, increase habitat diversity, and improve watershed conditions. Vegetation treatment programs also would be directed toward controlling undesired plant species in riparian zones, suppressing plants toxic to wildlife and domestic livestock, and controlling the expansion of exotic species that threaten native species and may invade adjacent agricultural and pasture lands.

Public Domain Forest Land Treatments

Public domain forest land treatments would be designed to meet a variety of multiple-use objectives, many of which are generally similar to objectives for rangeland treatments. These include reducing plant competition to enhance the growth of desired timber species and the growth of plant species that provide shelter and food for wildlife, restoring the ecological role of prescribed fire in the forest system to stimulate reproduction of certain species, removing noncommercial trees, and managing vegetation that could serve as fuel for wildfires.

Oil and Gas Site Treatments

Oil and gas drilling and production site operations frequently involve site disturbance, which often results in invasion of noxious weeds and other undesired vegetation. The goal of oil and gas site treatments is to control noxious weeds and vegetation that may pose a safety or fire hazard. Vegetation treatments include the preparation and regular maintenance of areas for use as fire control lines or fuel breaks, or the reduction of vegetation species that could pose a hazard to fire control operations.

Right-of-Way Treatments

Treatments for road, railroad, trail, waterway, utility rights-of-way, and communication sites are necessary to suppress vegetation that restricts vision or presents a safety or fire hazard. In roadside maintenance, vegetation is removed or retarded from ditches and shoulders to prevent brush encroachment into driving lanes, maintain visibility on curves for the safety of vehicle operators, permit drainage structures to function as intended, and facilitate maintenance operations. Railroad rights-of-way treatments are important for public safety, employee safety, drainage, inspections, fire prevention and communication lines and signals. In addition, poisonous plants on unfenced lands would be treated to protect the health of livestock.

Some of the reasons for using chemical vegetation control on railroad rights-of-ways include:

1. High standards of vegetation control are important in maintaining a safe operating environment for the railroads. Preemergence and post-emergence herbicides are the primary means use for preventing or controlling young emerged vegetation, **before** it becomes a safety hazard. Alternative methods, such as burning or mechanical control, present for greater risk to railroad employees and the general public, and pose a hazard to existing facilities.
2. Pre-emergence herbicides, which prevent the emergence of vegetation for the length of a growing season, are a particularly important tool for railroad vegetation management. Each time a piece of equipment occupies track limits, this may slow the movement of other freight.

Recreation and Cultural Area Treatments

Recreation and cultural area treatments would be directed toward maintaining the appearance of

these areas, reducing potential threats to the sites' plants and wildlife, and protecting visitors from adverse health effects of poisonous or harmful plants. Treatments also would be made to reduce vegetation that could serve as fuel for wildfires, as well as to establish fire-resistant and fire-resilient species in these areas.

Weed Management Treatments and Design Features

The purpose of this section is to discuss preventive measures, treatment methods, and protective measures (design features) that would be used in a noxious weed management program. Some acres may receive one or more treatments in combination, including such treatment combinations as herbicide application and burning, grazing and herbicide application, and grazing and use of insects or pathogens. Treatment would have to be repeated in most situations.

Pretreatment surveys would be conducted in accordance with BLM Manual 9011 and Handbook 9011-1 before a decision is made to use herbicides on a specific tract. Such surveys would involve consideration of all feasible treatments, including potential impacts, effectiveness, and cost. Information from such surveys would be used as a basis for prescribing noxious weed treatments.

Special provisions for treatments would be selected according to the scope of the action, accepted mitigation, and the physical characteristics of the specific site. BLM manuals, manual supplements, and field guides provide a variety of approved standard and special provisions. These provisions are updated periodically as pre- and post-treatment analysis finds a need for change. BLM will assure that noxious weed infestations are noted and considered during appraisals of any land proposed for exchange or sale.

Before any vegetation treatment or ground disturbance, BLM policy requires a survey of the project site for plants and animals listed or proposed for listing as theatened, endangered, and sensitive species (see Appendix H). If a project might affect any listed or proposed federal threatened or endangered species or its critical habitat, BLM would modify, relocate, or abandon the project to obtain a no effect determination.

When no effective alternatives to noxious weed control exist for wilderness study areas (WSAs), BLM's policy is to carry out a management program, but only in small areas. BLM is required to manage WSAs so as not to impair their suitability for preservation as wilderness. Therefore, some actions can occur in WSAs that would not be allowed in wilderness areas. These actions, however, could not im-pair wilderness values at the time the Secretary of the Interior submits his wilderness suitability recommendations to the President (BLM Interim Management Policy and Guidelines for Lands Under Wilderness Review, USDI, BLM 1979).

In wilderness areas, BLM's policy is to allow natural ecological processes to occur and to be interfered with only in rare circumstances. Noxious weeds would not ordinarily be controlled in wilderness areas unless these weeds threaten outside lands or are spreading within the wilderness. In those cases, noxious weeds may be grubbed manually or controlled with herbicides, provided the control can be effected without seriously impairing wilderness values (BLM Wilderness Management Policy—USDI, BLM 1981).

To determine if evidence of historic or prehistoric occupation existed prior to BLM activities, special surveys are undertaken to determine possible conflicts in management objectives. In addition, a Class III (complete) cultural resources inventory is required on all areas to be subjected to ground disturbance. This inventory is conducted in the preplanning stage of an action, and the results are analyzed in an environmental analysis addressing the action (BLM Manual H-1790-1). When a cultural resource that might be harmed is discovered during weed treatment, nearby operations are immediately suspended and may resume only upon receipt of written instructions from the BLM authorized officer. Procedures under 36 CFR 800 would be followed, including consultation with the State Historic Preservation Officer in determining eligibility for nomination to the National Register of Historic Places, effect, and adverse effects.

Preventive management is important in preventing or retarding the spread of noxious weeds. All weed species are spread by seed, vegetative reproduction parts such as rhizomes, tubers, corms, bulbs, and bulblets or both seed and vegetative reproductions parts. The method of spread of noxious weeds that has the greatest impact on all landowners is the continued spread by human activity through the use of vehicles, machinery or cargo equipment along highways, railroads, and rights-of-ways. Noxious weeds also spread downstream from sources of infestation by seed deposit into the water. Animals and birds also spread weeds by ingesting the seed, or having the seed attach to their hair, wool, fur, feathers, etć. and then later the seed dropping to the ground. Label restrictions dealing with buffer zones, feeding areas and holding pastures will be observed. Weeds can also be introduced by hay and other foodstuffs. Weeds have also been introduced in an area because they have been used as an ornamental and escaped from the original site by seed dispersal or vegetative reproduction. Sale of wildflower seeds and wild bird feed in some situations include seeds of such noxious weeds as knapweed or thistle, and should be checked prior to use.

PROPOSED ACTION AND ALTERNATIVES

The treatment methods and acreages included in the proposed action and alternative programs are detailed below. The total annual acreage treated would vary across program alternatives (Table 1-1). Tables 1-2 through 1-6 depict estimated average annual acres to be treated within each state and as proposed under alternative scenarios. The tables were developed in this Final EIS to better describe the origin of treatment acres proposed within the various states. (The five treatment methods—manual, mechanical, biological, prescribed burning, and chemical—are described in the Standard Operating Procedures section.)

The primary difference between the proposed action and Alternative 5, No Action Alternative, is that more treatment methods would be available for use on a greater number of acres in the proposed action than Alternative 5. Some untreated areas may be suitable to treatment by only one method (because of accessibility, cost, feasibility, or amount of surface disturbance acceptable) that is not yet approved for that area. Treatment of these additional acres is reflected in Alternative 1.

The treatment method(s) used in the treatment program selected would depend on characteristics of the soil and the target plant species; the location, size, terrain, and accessibility of the target area; and weather conditions prevalent at the time treatment is necessary.

Chemical or prescribed burning methods will be used to treat the greatest proportion of acres in all five alternatives; manual methods will be used for the smallest proportion of acres (Figure 1-4). Both the manual and mechanical treatment methods are labor intensive, so fewer acres can be treated in any given time period with the same number of workers than with prescribed burning or chemical treatments. In addition, costs of manual and mechanical methods are greater per acre treated than prescribed burning or chemical methods. In most cases, however, manual and mechanical treatment methods can be used under less restrictive weather conditions than chemical or prescribed burning methods.

Alternative 1: Proposed Action

All methods of vegetation treatment—manual, mechanical, biological, prescribed burning, and chemical—would be available to treat vegetation under the proposed action. This is the most flexible of all the alternatives because it would allow implementation of the most effective treatment method on each site.

An estimated average of 372,000 acres would be treated each year; approximately 64 percent of the acres would be treated with chemicals or prescribed burning.

Alternative 2: No Aerial Application of Herbicides

This program alternative also allows all five vegetation treatment methods to be used. However, the application method for chemical treatment would be restricted to ground-based techniques; only vehicle or manual application would be permitted.

The average annual acreage treated would be estimated at 323,000. Prescribed burning and mechanical methods would be used for approximately 63 percent of the acres treated. The elimination of aerial herbicide application would result in 13 percent fewer acres treated than under Alternative 1 because these acres cannot be treated by any other method.

Alternative 3: No Use of Herbicides

Four vegetation treatment methods would be used in this alternative: manual, mechanical, biological, and prescribed burning. Herbicides would not be used under any circumstance.

The estimated average number of acres treated would be 285,000 per year, with prescribed burning and mechanical methods used on approximately 74 percent of the acreage. About 23 percent fewer acres would be treated in this alternative than in Alternative 1 because they cannot be treated by manual, mechanical, biological, or prescribed burning methods.

Alternative 4: No Use of Prescribed Burning

Under this alternative, vegetation treatment would be limited to manual, mechanical, biological, and chemical methods. Prescribed burning would not be used.

The annual estimated acreage treated would average 318,000. Chemical treatments would be used on approximately 55 percent of the acres. About 14 percent fewer acres would be treated with this program alternative than with Alternative 1; these acres may not be effectively treated by any other method.

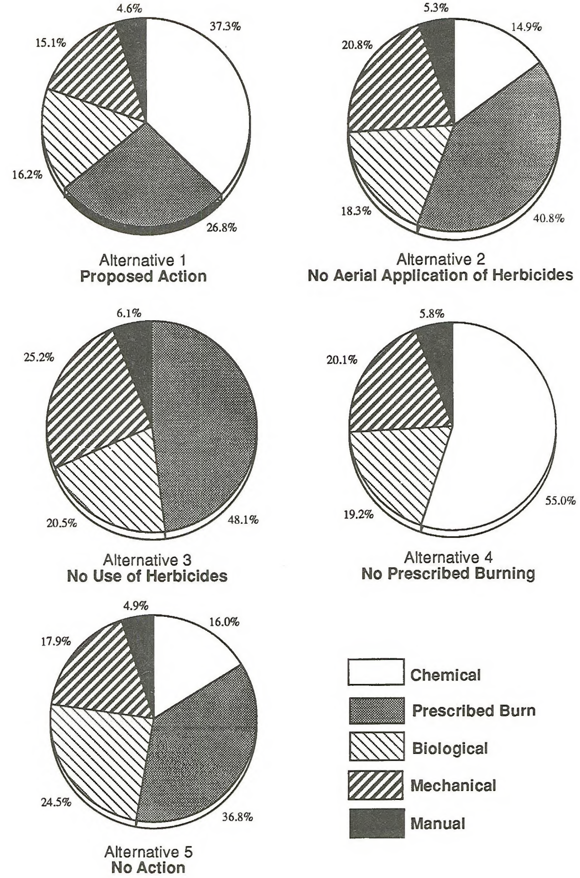


Figure 1-4
Proportion of Acreage Treated Annually by Treatment Method

Alternative 5: No Action (Continue Current Management)

BLM would continue IPM vegetation treatment programs under this alternative. An estimated 243,000 acres would be treated annually using manual, mechanical, biological, prescribed burning, and chemical methods. Approximately 62 percent would continue to be treated using prescribed burning and biological methods.

STANDARD OPERATING PROCEDURES

This section summarizes the available treatment methods and standard operating procedures that would be used in a vegetation treatment program. BLM policies and guidance for public land treatments would be followed in implementing all treatment methods. Many guidelines are provided in Manual Section 1740, Renewable Resource Improvements and Treatments (BLM 1985b); Manual Section 1741, Renewable Resource Improvements, Practices, and Standards (BLM 1985c); Handbook H-1740-1, Renewable Resource Improvement and Treatment Guidelines and Procedures (BLM 1987b); and Manual Section 9220, Integrated Pest Management (BLM 1981a). Appendix J lists many other references for general and specific program policy, procedures, and standards pertinent to implementation of renewable resource improvements.

BLM could use any of the five treatment methods summarized below to suppress undesired vegetation. Operational details of the manual, mechanical, biological, and prescribed burning methods are presented in Appendix C; chemical operations are described in Section 2 of Appendix E.

Vegetation treatment methods are selected based on several important parameters that include (1) the characteristics of the target plant species (size, distribution, density, and life cycle); (2) associated plant species; (3) the land use of the target area; (4) the size, slope, accessibility, and soil characteristics (rockiness and erodibility) of the area to be treated; (5) climatic conditions present at the time of treatment (for example, wind speed, precipitation, or season); (6) the proximity of the area targeted for vegetation treatment to sensitive areas (for example, threatened and endangered plant or animal habitat, riparian zones, significant aquatic resources and unstable watersheds, or areas of human or livestock habitation); (7) need for subsequent revegetation, and (8) time of year treatment could occur. Site-specific analyses consider all these factors before a treatment method is selected.

Reseeding is sometimes required after treatment when remaining vegetation is present in insufficient quantity to naturally reseed the site. Site-selection factors important for successful seeding, which are part of the decision process for the whole treatment, include adequate soil for root development and moisture storage, adequate moisture to support the species seeded, and minimal rockiness and slope. Chances for seeding success are also improved by selecting seed with high purity and percentage germination, planting at proper depth, planting at the right time of year for the region, selecting an appropriate seeding rate for the method of seeding, and determining whether broadcast seeding will be adequate or whether drilling will be required.

All values and uses of a site dictate selection of a seed mixture. Some of these considerations include maintaining vegetative diversity for rangeland and wildlife uses, improving recreation and aesthetic values, and improvement of watershed values. The most satisfactory mixtures for most rangeland situations include a combination of adapted grasses, forbs, and shrubs. Forbs and shrubs in particular can enhance the value of a treated site for wildlife, and excellent forb and shrub varieties and ecotypes adapted to many rangeland situations are available. Mixtures can better take advantage of variable soil, terrain, and climatic conditions and are more likely to withstand insect infestations and survive adverse climatic conditions. Once the site has been seeded, it is important to allow seeded vegetation to establish. On most rangeland seeding, this usually means no grazing for two full growing seasons following seeding, and longer if dry conditions prevail during the establishment period.

During site specific analysis and preliminary planning of weed management programs, some of the considerations taken will be:

A. Management program/objective for the site.

B. Total acres in the unit.

C. Number of acres infested with weed in the unit.

D. Predominant weed species in the unit.

E. Predominant non-target plant species in the unit.

F. Consideration of all feasible pest management alternatives, including:

    (1) Identification of environmental effects on fish, wildlife, soil, ground and surface water, air, rare/endangered plants and animals, nontarget plants and culture sites.

    (2) Human health hazard(s) associated with each method.

    (3) Effectiveness of each method (retreatment needs).

(4) Cost of each method.

(5) Cost of each method regarding hazards to nontarget species.

(6) Map of survey unit(s).

(7) Growth characteristics, sensitivity to treatment method, stage of growth, life span, etc. of both target and nontarget plant species at the time of treatment.

G. Recommended treatment method(s), or combination of methods.

H. If chemical pesticides are recommended, the following additional information is required:

(1) Pesticide common names, application rate, carrier.

(2) Posting requirements (if needed).

(3) Positive placement techniques planned to minimize drift and effects on nontarget areas.

(4) Method of application (ground, aerial, backpack).

(5) Special restrictions on the pesticide label or BLM regulations with regard to handling, buffer strips, grazing, re-entry, wind, droplet size, etc.

(6) Monitoring plans (water, efficacy, nontarget effects, target effects, etc.)

Generally, mechanical treatment would avoid areas of high slope (greater than 20 to 30 percent); areas of high erosion hazard where vegetation cover is adequate; areas where revegetation potential is low; areas frequently impacted by high precipitation events; and areas having high potential for compaction. Buffer strips would be left around water courses and drainages. Soil disturbing activities would be perpendicular to the slope, where possible, to reduce concentrating the water.

Usually, biological methods using ungulates would avoid erosion hazard areas, areas of compactible soils, riparian areas susceptible to bank damage, and steep erodible slopes.

Treatment Method Descriptions

Manual

Hand-operated power tools and hand tools are used in manual vegetation treatment to cut, clear, or prune herbaceous and woody species. Under the proposed action, approximately 4 percent of the treatment areas (14,000 acres) would be treated in this manner. In manual treatments, workers would cut plants above ground level; pull, grub, or dig out plant root systems to prevent subsequent sprouting and regrowth; scalp at ground level or remove competing plants around desired vegetation; or place mulch around desired vegetation to limit the growth of competing vegetation.

Hand tools such as the hand saw, axe, shovel, rake, machete, grubbing hoe, mattock (combination of axe and grubbing hoe), brush hook, and hand clippers are used in manual treatments. Axes, shovels, grubbing hoes, and mattocks can dig up and cut below the surface to remove the main root of plants such as prickly pear and mesquite that have roots that can quickly resprout in response to surface cutting or clearing. Workers also may use power tools such as chain saws and power brush saws.

Although the manual method of vegetation treatment is labor intensive and costly, compared to prescribed burning or herbicide application, it can be extremely species selective and can be used in areas of sensitive habitats or areas that are inaccessible to ground vehicles.

Mechanical

BLM uses wheel tractors, crawler-type tractors, or specially designed vehicles with attached implements for mechanical vegetation treatments (Figure 1-5). About 16 percent (58,000 acres) of the proposed vegetation treatments would use mechanical methods. The best mechanical method for treating undesired plants in a particular location depends on the following factors: (1) characteristics of the undesired species present (for example, density, stem size, brittleness, and sprouting ability); (2) need for seedbed preparation and revegetation; (3) topography and terrain; (4) soil characteristics (for example, type, depth, amount and size of rocks, erosiveness, and susceptibility to compaction); (5) climatic conditions; and (6) potential cost of improvement as compared to expected productivity.

Biological

Biological methods of vegetation treatment employ living organisms to selectively suppress, inhibit, or control herbaceous and woody vegetation (Figure 1-6). This method is viewed as one of the more natural processes because it requires the proper management of plant-eating organisms and precludes the use of mechanical devices, chemical treatments, or burning of undesired vegetation. Approximately 16 percent (60,000 acres) of BLM's proposed vegetation treatment program would use biological methods.

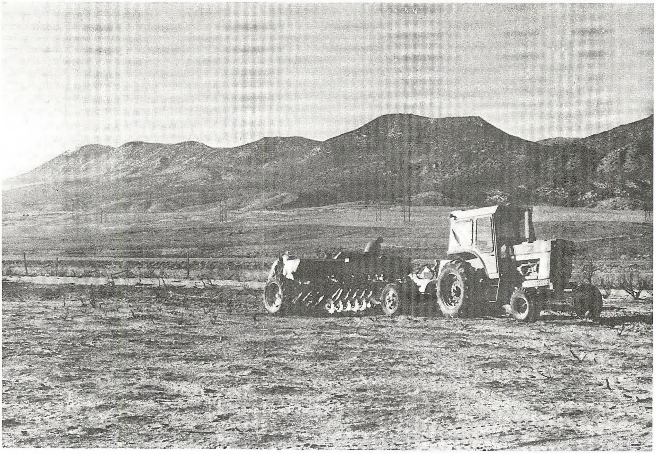


Figure 1-5. Mechanical disking equipment.

The use of biological control agents will be conducted in accordance with BLM procedures in the Use of Biological Control Agents of Pests on Public Lands (BLM 1990). Insects, pathogens, and grazing by cattle, sheep or goats would be used as biological control methods under all alternatives, although at the present these methods can control few plant species. Insects are the main natural enemies being used at the present time. Other natural enemies include mites, nematodes and pathogens. This treatment method will not eradicate the target plant species but merely reduces the target plant densities to more tolerable levels. This method also reduces competition with the desired plant species for space, water and nutrients. This treatment method will be used on larger sites where the target plant has become established and is strongly competitive.

Generally, biological methods using cattle, sheep, or goats would avoid erosion hazard areas, areas of compactible soils, riparian areas susceptible to bank damage, and steep erodible slopes.

Biological control using cattle, sheep or goats would be applied to treatment areas for short periods. When considering the use of grazing animals as an effective biological control measure, several factors will be taken into consideration including:

(1) target plant species present,

(2) size of the infestation of target plant species,

(3) other plant species present,

(4) stage of growth of both target and other plant species,

(5) palatability of all plant species present,

(6) selectivity of all plant species present by the grazing animal species that is being considered for use as a biological control agent,

(7) the availability of that grazing animal within the treatment site area, and

(8) type of management program that is logical and realistic for the specific treatment site.

These factors will be some of the options taken when developing the individual treatment for a specific site.

Although discussed as biological agents, cattle, sheep and goats are not truly biological agents but are domestic animals used to control only the topgrowth of certain noxious weeds. The following are some advantages of using domestic animals, mainly sheep or goats, for noxious weed control: (1) they use weeds as a food source, (2) following a brief adjustment period, they sometimes consume as much as 50 percent of their daily diet of this species, (3) average daily gains of offspring grazing certain weed-infested pastures can sometimes be significantly higher than average daily gains of offspring grazing grass pastures, and (4) sheep or goats can be used in combination with herbicides.

Some of the disadvantages of using domestic animals are (1) they also use nontarget plants as food sources, (2) the use of domestic animals, like sheep or goats, requires a herder or temporary fencing, (3) the animals may be killed by predators such as coyotes, (4) heavy grazing of some weed species, such as leafy spurge, tends to loosen the stool of the grazing animals, and (5) most weed species are less palatable than desirable vegetation and would cause overgrazing.

Particular insects, pathogens or combinations of these biological control agents may also be introduced into an area of competing or undesired vegetation to selectively feed upon or infect those target plants and eventually reduce their density within that area. Only on rare occasions will one specific biological control agent reduce the target plant density to the desired level of control. Therefore in most situations, a complex of biological control agents is needed to reduce the target plant density to a desirable level. But even with a complex of biological control agents, often 15 to 20 years are needed to bring about an economic control level, especially on creeping perennials. In most circumstances, biological control agents are not performing control. They are only creating stresses on the weeds, which is not the same as control.

Figure 1-6. Grazing biological treatment using sheep.

As biological control agents become available, BLM will continue to increase their use. See Appendixes C2, C3 & C4 for the lists of biological control agents that are currently being considered for use.

Some of the advantages of using natural enemies to control weeds are that (1) they are self-perpetuating, (2) they can be comparatively economical once studied and established, (3) they can be highly selective, (4) they offer a high degree of environmental safety, and (5) they do not require fossil fuel energy.

Biological control, however, does have limitations because (1) it is a slow process, (2) it does not achieve eradication but merely reduces weed densities to more tolerable levels, (3) it is highly selective, attacking one weed existing among a complex of other weeds, (4) it cannot be used against weeds that are valued under some situation because insects or pathogens do not recognize boundaries, (5) it cannot be used against weeds that are closely related to beneficial plants because the insects or pathogens may be unable to discriminate between related plant species, and (6) it cannot be used against weeds when the biological control agent requires an alternate host that may be a beneficial plant.

To develop a biological weed control program, the following steps must be taken:

(1) Identify weed species and determine origin.

(2) Determine if any natural enemies occur at the point of origin.

(3) If possible, collect natural enemies.

(4) Hold preliminary screening trials on the natural enemies of the weed in the United States.

(5) Hold further screening trials in the United States.

(6) Raise biological control agents before first release.

(7) Release biological control agents for the first time onto selected sites.

(8) If biological control agents survive and increase in numbers, collect agents and release onto other sites of weed infestation.

Usually a complex of at least three to five different biological agents, such as insects, must be used to attack an individual weed infestation site. But even with a complex of biological agents, often 15 to 20 years are needed to bring about an economic control level, especially on creeping perennials.

Prescribed Burning

Prescribed burning is the planned application of fire to wildland fuels in their natural or modified state, under specified conditions of fuels, weather, and other variables, to allow the fire to remain in a predetermined area and to achieve site-specific fire and resource management objectives (Figure 1-7).

Management objectives of prescribed burning include the control of certain species; enhancement of growth, reproduction, or vigor of certain species; management of fuel loads; and maintenance of vegetation community types that best meet multiple-use management objectives. Treatments would be implemented in accordance with BLM procedures in Fire Planning (BLM 1987c), Prescribed Fire Management (BLM 1988b), and Fire Training and Qualifications (BLM 1987d).

Chemical

Treatments would be conducted in accordance with BLM procedures in Chemical Pest Control (BLM 1988c). Treatments would meet or exceed individual States' label standards. The chemicals can be applied by many different methods, and the selected

Figure 1-7. Drip torch used to ignite a prescribed burn.

technique depends on a number of variables. Some of these are (1) the treatment objective (removal or reduction); (2) the accessibility, topography, and size of the treatment area; (3) the characteristics of the target species and the desired vegetation; (4) the location of sensitive areas in the immediate vicinity (potential environmental impacts); (5) the anticipated costs and equipment limitations; and (6) the meteorological and vegetative conditions of the treatment area at the time of treatment.

Herbicide applications are scheduled and designed to minimize potential impacts on nontarget plants and animals, while remaining consistent with the objective of the vegetation treatment program. The rates of application depend on the target species, presence and condition of nontarget vegetation, soil type, depth to the water table, presence of other water sources, and the requirements of the label.

In many circumstances the herbicide chosen, time of treatment, and rate of application of the herbicide is different than the most ideal herbicide application for maximum control of the target plant species in order to minimize damage to the nontarget plant species, and to ensure minimum risk to human health and safety.

The chemicals would be applied aerially with helicopters (Figure 1-8) or fixed-wing aircraft or on the ground using vehicles or manual application devices. Helicopters are more expensive to use than fixed-wing aircraft, but they are more maneuverable and effective in areas with irregular terrain and in treating specific target vegetation in areas with many vegetation types. Manual applications are used only for treating small areas or those inaccessible by vehicle.

Nineteen herbicides were proposed for use in the vegetation treatment program. However, after impact and risk assessment analyses, 17 are proposed for use in the vegetation treatment program. BLM has reexamined the risk assessment and examined additional data for amitrole. BLM has determined that amitrole is no longer considered for proposed use in this document. Amitrole will be deleted in the Record of Decision. Since drafting this document, producers are no longer manufacturing dalapon formulations registered for proposed use. Therefore, dalapon is no longer considered for use. However, information on all 19 herbicides is included throughout the document.

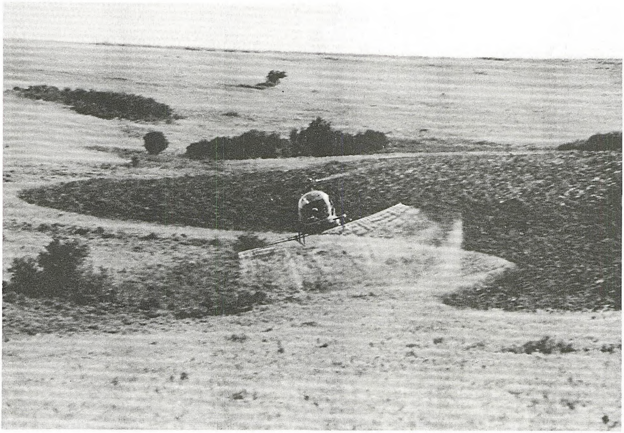


Figure 1-8. Helicopter herbicide application.

The typical and maximum application rates of each would vary, depending on the program area being treated (Tables 1-7 and 1-8). Toxicity and environmental fate summaries for each herbicide are provided below. (References for these discussions are given in Appendix E.)

Toxicity and Environmental Fate Summaries

Amitrole. Amitrole is a broad-spectrum herbicide used for controlling a wide range of grasses and broadleaf weeds. It is registered for use on many noncrop sites, including rights-of-way, marshes and drainage ditches, ornamentals, and commercial, industrial, agricultural, and domestic properties. Amitrole is readily absorbed and translocated by roots and leaves and prevents normal plant growth by disrupting chloroplast development, bud regrowth, and the metabolism of nucleic acid precursors.

A crystalline, colorless, and odorless compound, amitrole is soluble in some polar solvents and stable in heat to 100° C (212° F). Amitrol T™, a commonly used formulation manufactured and marketed by the Rhone-Poulenc Company, contains 21.5 percent (2 lbs/gal) amitrole and 78.4 percent inert ingredients.

Evidence suggests that amitrole produces slight to very slight acute effects in mammals. The thyroid and pituitary glands seem to be the primary target organs in rat feeding studies. Rat feeding studies also have demonstrated consistently an oncogenic potential, and consequently EPA has classified amitrole as a probable carcinogen. In the herbicide risk assessment conducted for this final EIS, amitrole was assumed to be carcinogenic. However, no mutagenic or teratogenic effects have been noted in laboratory studies. Amitrole is only slightly toxic to fish and crayfish, very slightly toxic to birds, and moderately toxic to aquatic invertebrates.

Table 1-7

Typical Herbicide Application Rates by Area (pounds active ingredient per acre)

Herbicide	Trade Name(s)[1]	Rangeland	Public Domain Forest Land	Oil and Gas Sites[2]	Rights-of-Way on Public Land	Recreation Sites[3]
Amitrole	Amitrol-T	2	2	4	2	—
Atrazine	AAtrex, Atratol	1	4	10	4	1
Bromacil	Hyvar X	—	—	8	8	—
Bromacil + Diuron	Krovar 1	—	—	8	8	—
Chlorsulfuron	Telar	—	2 oz	2.25 oz	2.25 oz	2 oz
Clopyralid	Reclaim, Stinger	0.5	—	—	12	12
2,4-D	Clean Crop, DMA4, Esteron 99, Weedar, Weedone	4	4	4	4	3
Dalapon	Dalapon 85	3	4	4	4	4
Dicamba	Banvel	4	4	8	4	4
Diuron	Karmex	—	—	10	4	—
Glyphosate	Rodeo, Roundup, Accord	4	2	4	4	4
Hexazinone	Velpar	0.67	2	4	2	2
Imazapyr	Arsenal	1	1.5	1.5	1.5	1.5
Mefluidide	Embark	—	—	0.25	0.25	—
Metsulfuron Methyl	Escort	—	—	1.2 oz	1.2 oz	—
Picloram	Grazon PC Tordon	2	2	3	3	2
Simazine	Princep 80W, Princep 4G, Aquazine, Simazine 80W	—	4	10	4	1
Sulfometuron Methyl	Oust	—	—	9 oz	9 oz	—
Tebuthiuron	Graslan, Spike	0.5	1.5	6	1.5	0.5
Triclopyr	Garlon, Grazon ET	1.5	2	4	4	1.5

[1] For a complete listing of formulations available for use, see Appendix M. These formulations have been investigated to insure that they contain no inerts on Lists 1 or 2 of the Environmental Protection Agency (EPA) lists of inerts.

[2] Includes oil and gas drilling and production facilities, pipelines, powerlines, and roads on public land.

[3] Includes developed recreation sites, Recreation and Public Purpose (R&PP) sites, and cultural and historical sites on public land.

Table 1-8

Maximum Herbicide Application Rates by Area (pounds active ingredient per acre)

Herbicide	Trade Name(s)[1]	Rangeland	Public Domain Forest Land	Oil and Gas Sites[2]	Rights-of-Way on Public Land	Recreation Sites[3]
Amitrole	Amitrol-T	2	2	9.9	9.9	—
Atrazine	AAtrex, Atratol	1	4	40	40	1
Bromacil	Hyvar X	—	—	16	16	—
Bromacil + Diuron	Krovar 1	—	—	20	20	—
Chlorsulfuron	Telar	—	2 oz	2.25 oz	2.25 oz	2 oz
Clopyralid	Reclaim, Stinger	0.5	—	—	12	12
2,4-D	Clean Crop, DMA4, Esteron 99, Weedar, Weedone	6	8	4	4	3
Dalapon	Dalapon 85	3	4	22	22	4
Dicamba	Banvel	8	4	8	8	8
Diuron	Karmex	—	—	32	32	—
Glyphosate	Rodeo, Roundup, Accord	5	3	4	4	5
Hexazinone	Velpar	0.67	3	10.8	10.8	3
Imazapyr	Arsenal	1	1.5	1.5	1.5	1.5
Mefluidide	Embark	—	—	0.25	0.25	—
Metsulfuron Methyl	Escort	—	—	1.2 oz	1.2 oz	—
Picloram	Grazon PC Tordon	2	2	3	3	2
Simazine	Princep 80W, Princep 4G, Aquazine, Simazine 80W	—	4	10	10	4
Sulfometuron Methyl	Oust	—	—	9 oz	9 oz	—
Tebuthiuron	Graslan, Spike	4	5	6	6	4
Triclopyr	Garlon, Grazon ET	1.5	4	8	8	1.5

[1] For a complete listing of formulations available for use, see Appendix M. These formulations have been investigated to insure that they contain no inerts on Lists 1 or 2 of the Environmental Protection Agency (EPA) lists of inerts.

[2] Includes oil and gas drilling and production facilities, pipelines, powerlines, and roads on public land.

[3] Includes developed recreation sites, Recreation and Public Purpose (R&PP) sites, and cultural and historical sites on public land.

Microbiological breakdown is approximately 2 to 3 weeks in moist, warm soil. This breakdown period would be greater under drier conditions. Loss due to photolysis and volatilization is minor. Adsorption is considered strong but reversible. Mobility is considered moderate with a solubility in water of 280,000 ppm. The persistence is considered short to moderate with a half-life less than 1 to 6 months.

Atrazine. Atrazine is a selective triazine controlling herbicide used for broadleaf and grassy weeds. It is registered for use with a variety of grains and fruits, rangeland, turf grass sod, conifer reforestation, Christmas tree plantations, grass in orchards, proso millet, ryegrass (perennial), grass seed fields, nonselective vegetation control in chemical fallow, and noncrop lands. Atrazine is absorbed through roots and foliage and acts as a photosynthetic inhibitor.

Pure atrazine is a white, crystalline solid. The two brands of atrazine proposed for use on BLM lands, AAtrex™ and Atratol™, are manufactured by the Ciba-Geigy Corporation.

Atrazine is slightly toxic to mammals for acute oral exposure and dermal effects but is moderately toxic as an eye irritant. Effects to the kidneys have been observed in rats, including increased ion elimination, decreased creatinine clearance, increased urine protein levels, and increased lactate dehydrogenase activity. Based on chronic feeding/oncogenicity studies, EPA has classified atrazine as a possible human carcinogen. Consequently, atrazine was assumed to be a carcinogen in the herbicide risk assessment conducted for this final EIS. Although all EPA-validated mutagenicity assays are negative, studies in the open literature suggest that atrazine is a possible human germ cell mutagen. Atrazine is moderately to highly toxic to fish and aquatic invertebrates and is highly toxic and teratogenic to immature fish and amphibians. It is of low toxicity to birds.

Microbiological breakdown possibly accounts for a significant portion of atrazine decomposition in soil. Adsorption on soil particles readily occurs but is not strong. Atrazine normally is not found below the upper foot of soil in detectable quantities. Pho-

tolysis and volatilization occur to some extent if high temperatures and prolonged sunlight follow application before precipitation. Mobility is considered moderate with a solubility in water of 33 ppm. Soil half-life persistence is 18 to 120 days. See Table 3-6.

Bromacil. Bromacil is used on noncropland areas to control a wide range of annual and perennial grasses and broadleaf weeds and certain woody species. The herbicide also is used for the selective control of annual and perennial weeds in citrus fruit orchards and for seedling weeds in pineapple orchards. A combination of bromacil and diuron is used in citrus and noncropland areas. Bromacil is readily absorbed through root systems and is a potent inhibitor of photosynthesis.

Pure bromacil is a white, odorless, crystalline solid that is stable in water, aqueous bases, and common organic solvents. E.I. du Pont de Nemours & Company manufactures the two formulations proposed for use on BLM lands, Hyvar™X and Krovar™1. Hyvar™X contains 80 percent bromacil and 20 percent inert ingredients, while Krovar™1 contains a mixture of bromacil (40 percent) and diuron (40 percent) and 20 percent inert ingredients.

Bromacil is slightly toxic to mammals during acute exposure, a mild eye irritant, and a very slight skin irritant. In a chronic toxicity study with rats, lowered growth rates, decreased erythrocyte counts, increased thyroid activity, and the enlargement of centrolobular cells of the liver have been observed. Given the occurrence of carcinomas and hepatocellular adenomas in a chronic mouse feeding/oncogenicity study, EPA has classified bromacil as a possible human carcinogen. Accordingly, bromacil was assumed to be a carcinogen in the herbicide risk assessment conducted for this final EIS. Bromacil has no demonstrated teratogenic or fetotoxic effects and is considered nonmutagenic by EPA. However, it is slightly toxic to birds and aquatic organisms.

Microbiological breakdown is considered a mode of breakdown. Its adsorption on soils is considered low. Mobility is high as with its solubility in water of 132,000 ppm. Soil half-life persistence of bromacil acid is 60 to 360 days, and bromoxynil octanoate ester is 1 to 14 days. See Table 3-6.

Chlorsulfuron. Chlorsulfuron is an herbicide used for controlling many common broadleaf weeds and certain grassy weeds in the cereal crops of wheat, barley, and oats; it also may be used in the fallow period before planting. Chlorsulfuron is absorbed rapidly by foliage and causes inhibition of cell division.

Pure chlorsulfuron is an odorless, white, crystalline solid that is stable under normal use conditions. The formulation proposed for use by BLM is made by Du Pont and is marketed under the name Telar™. This formulation is 75 percent active ingredient by weight.

Based on studies with rats and rabbits, chlorsulfuron is considered to be very slightly toxic to mammals during acute oral and dermal exposures. Also, available data indicate that chlorsulfuron is noncarcinogenic and nonmutagenic. Chlorsulfuron is practically nontoxic to fish and is of low toxicity to birds.

Metabolism through normal soil microbial processes occur. Hydrolysis is an important degradation mechanism while photolysis and volatization play minor roles. Adsorption to clay is low. Its solubility is high in water of neutral pH and several magnitudes lower in low pH water. Low pH water accelerates hydrolysis. Soil half-life persistence is 28 to 160 days. See Table 3-6.

Clopyralid. Clopyralid is a systemic, postemergent herbicide that is effective against many species of Compositae, Fabaceae, Solanaceae, and Apiaceae. It is selective in graminaceous crops, as well as broad-leaved crops, such as brassicas, sugar beets, flax, strawberries, and onion-type crops. It may also be applied to cereal crops in combination with other herbicides. It has auxin-like activity, inducing severe epinasty and hypertropy of the crown and leaves.

Pure clopyralid forms colorless crystals. Its melting point is approximately 151° C (304° F). It is soluble in water and is acidic. Clopyralid forms salts, which in solution are corrosive to aluminum, steel, and tinplate. The brands proposed for use on BLM lands, Reclaim™ and Stinger™, are manufactured by the Dow Chemical Company.

Clopyralid is classified as slightly to very slightly toxic to mammals. It is a severe eye irritant, however. Oncogenicity and mutagenicity studies suggest that clopyralid is noncarcinogenic and nonmutagenic. Clopyralid has a low order of toxicity for fish and aquatic invertebrates and is nontoxic to bees.

Microbial decomposition appears to occur. Photolysis is not important in decomposition. Does not appear to be strongly sorbed on soil and may be subject to leaching. Solubility is high. Persistence is low with the half-life being in the range of 12 to 70 days for clopyralid amine salt. See Table 3-6.

2,4-D. 2,4-D is a systemic herbicide widely used to control broadleaf weeds in wheat, field corn, grain sorghum, sugar cane, rice, barley, and rangeland and pastureland. 2,4-D is absorbed by plant roots

and leaves and causes abnormal growth response and affects respiration, food reserves, and cell division.

Pure 2,4-D forms white, odorless crystals, with a melting point of 140° C (284° F). Some formulations proposed for use by BLM include Clean Crop™ (Platte Chemical Company), DMA4™ (Dow Chemical), Esteron 99™ (Dow Chemical), Weedar™ (Rhone-Poulenc), and Weedone™ (Rhone-Poulenc).

Acute oral toxicity studies indicate that 2,4-D is moderately toxic to mammals. It is a severe eye irritant. Ingestion or skin exposure to 2,4-D by humans may produce many different symptoms, including irritation to the gastrointestinal tract, chest pain, and muscle twitching. Ingestion of large doses of the herbicide may cause gastroenteritis, skeletal and cardiac myotonia, and central nervous system depression. However, there is little conclusive evidence of 2,4-D carcinogenicity, and the results of many oncogenicity studies are disputed. Because of this uncertainty, 2,4-D was assumed to be carcinogenic in the herbicide risk assessment conducted for this final EIS. Although mutagenicity findings are similarly inconclusive, 2,4-D cannot be ruled out as a weak mutagen. 2,4-D is moderately to highly toxic for aquatic species, with amphipods and snails among the most sensitive groups. In addition, 2,4-D is moderately toxic to some species of birds.

2,4-D has a moderate mobility with a high solubility in its acid form. Its adsorption to soil is not strong. Soil half-life persistence of 2,4-D acid is 2 to 16 days, and of 2,4-D esters is 2 to 41 days. See Table 3-6.

Dalapon. Dalapon is used to control annual and perennial grasses. Registered uses include noncropland areas, such as railroads, conifer planting sites, fence rows, and ditch banks. Dalapon also may be used for the preplanting of crops such as sugar beets, beans, corn, and potatoes and on existing crops, such as asparagus, citrus, field corn, cotton, flax, potatoes, apples, pears, apricots, peaches, plums, and grapes. Dalapon is readily absorbed by roots and leaves and interferes with meristematic activity in root tips and apical meristems.

Dalapon sodium salt is a nonflammable, hygroscopic, white-to-tan colored powder, with a melting point of 193° to 197° C (379° to 387° F). Dalapon 85™, a formulation manufactured by the Fermenta ASC Corporation, is proposed for use on BLM lands.

Dalapon is classified as very slightly toxic to mammals during acute oral exposure. It also is slightly toxic as a skin and eye irritant. No teratogenic or reproductive effects have been observed in rats, but data gaps currently exist in these areas. Also, no carcinogenic effects have been observed in laboratory studies, and EPA has determined that dalapon is not classifiable in its human carcinogenicity criteria because of insufficient study data. Available data indicate that dalapon is nonmutagenic. Dalapon is slightly toxic to birds and fish and is relatively nontoxic to honey bees. The toxicity of the herbicide to aquatic invertebrates, however, is quite variable; some species are sensitive to dalapon exposure, while others are fairly tolerant.

Dalapon breaks down completely in soils through microbial processes. It has no adsorption on soils. The solubility is high, and its mobility is considered moderate. Its persistence is short, less than 1 month.

Dicamba. Dicamba is an herbicide used in postemergent weed control in field corn, wheat, oats, barley, sorghum, pastureland and rangeland, turfgrass, and industrial brush control and noncrop areas, such as fence rows, roadways, and wastelands. Dicamba is readily absorbed by leaves and roots and is concentrated in the metabolically active parts of plants. Toxic effects of dicamba are related to its growth-regulating properties and are similar to those of 2,4-D.

Pure dicamba is a white, crystalline, odorless solid. The melting point of dicamba is between 114° to 116° C (237° to 241° F). Banvel™, the formulation proposed for use on BLM lands, is manufactured by Sandoz Crop Protection Corporation and contains 49 percent active ingredient.

Based on acute oral exposures, dicamba is classified as slightly toxic to mammals. Also, it is a very slight skin irritant. However, dicamba is classified as a severe eye irritant. No teratogenic or reproductive effects have been noted for dicamba. Also, oncogenicity studies with dicamba have not demonstrated any carcinogenic potential, and the herbicide is currently not classifiable in EPA's human carcinogenicity criteria. Mutagenicity tests suggest that dicamba is nonmutagenic. For wildlife, technical dicamba and various formulations are considered to be slightly toxic to birds and most aquatic species but are moderately toxic to insects.

Microbiological breakdown is a major mode of decomposition. There is some information showing it degrades from photodecomposition. Its mobility is high as is its solubility. Soil half-life persistence of dicamba salt is 3 to 35 days. See Table 3-6. Studies have shown that dicamba can be leached out in humid areas in less than 3 months.

Diuron. Diuron is a substituted urea compound registered for use as an herbicide to control a wide variety of annual and perennial broadleaf and grassy weeds. Diuron is registered for use on forage crops, field crops, fruits, vegetables, nuts, and ornamental crops. In noncrop applications, diuron is used on

industrial sites, rights-of-way, and irrigation and drainage ditches. Diuron is readily absorbed by the root system and is a strong inhibitor of the Hill reaction.

A white, crystalline solid, diuron melts at 180° to 190° C (356° to 374° F). Karmex™, manufactured by Du Pont, is the formulation proposed for use by BLM and contains 80 percent diuron. Acute oral toxicity studies indicate that diuron is slightly toxic to mammals. With sufficient exposure, however, diuron facilitates nervous system depression, and the resulting symptoms include slowed respiration and heart rate, weakness, and lethargy. Diuron is only very slightly toxic to mammals through skin and eye exposure. No reproductive or teratogenic effects have been observed, and, given the lack of clear evidence of carcinogenicity, diuron is presently not classifiable as a human carcinogen. However, EPA has determined that additional teratology, mutagenicity, and carcinogenicity studies must be submitted in support of diuron's registration. Diuron is very slightly toxic to birds, moderately toxic to fish, and highly toxic to certain aquatic invertebrate species.

Microbial processes are important in its breakdown. Photolysis and volatization are not important. Its adsorption to clay and organic matter is high. Its mobility is moderate and has a solubility of 42 ppm. Soil half-life persistence is 30 to 328 days. See Table 3-6.

Glyphosate. Glyphosate is a very broad-spectrum herbicide that is relatively nonselective and is very effective on deep-rooted perennial species and annual and biennial species of grasses, sedges, and broadleaf weeds. Glyphosate is absorbed by the foliage and translocated throughout the plant. The herbicide appears to inhibit the aromatic amino acid biosynthesis pathway and is a strong inhibitor of sprouting by perennial species.

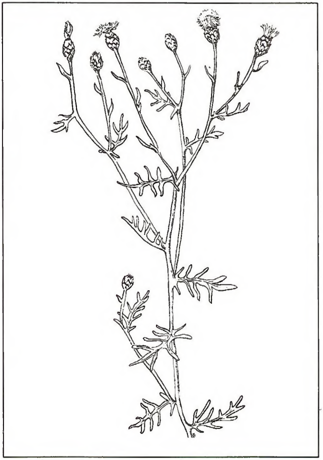
Glyphosate is a white, odorless solid that melts at 200° C (392° F). The Rodeo™, Roundup™, and Accord™ formulations of glyphosate, manufactured by Monsanto, are proposed for use by BLM.

Technical glyphosate and its two primary formulations, Roundup™ and Rodeo™, are classified as slightly toxic to mammals. Also, no reproductive or teratogenic effects have been noticed in laboratory animals exposed to glyphosate. Because of the inadequacy of current oncogenicity studies, the carcinogenic potential of glyphosate has not been determined by EPA. However, glyphosate was assumed to be carcinogenic in the herbicide risk assessment conducted for this final EIS. Available data suggest that glyphosate is nonmutagenic. For wildlife, glyphosate is considered slightly toxic to birds and relatively nontoxic to honey bees. Also, technical glyphosate and the Rodeo™ formulation are slightly to practically nontoxic to fish and aquatic invertebrates. The surfactants in Roundup™, however, render this formulation far more toxic to aquatic organisms than the other formulations. Roundup™ is instead slightly to moderately toxic to fish and aquatic invertebrates.

Microbial processes are important in its breakdown. Photolysis and volatization are not important. Its adsorption to soils is strong. It has a low to moderate mobility and a high solubility. Soil half-life persistence of glyphosate amine salt is 21 to 60 days. See Table 3-6.

Hexazinone. Hexazinone is used for contact and residual control of many annual, biennial, and perennial weeds, woody vines, and brush. Registered uses include fruit, sugar cane, alfalfa, pastureland and rangeland, rights-of-way, Christmas tree plantations, and conifer forest plantings. Hexazinone is readily absorbed through foliage and roots and acts as a photosynthesis inhibitor.

Hexazinone is a white, crystalline solid, soluble in water, with a melting point of 115° to 117° C (239°



Spotted Knapweed

to 243° F). Velpar™, a commonly used formulation manufactured by Du Pont, contains 90 percent hexazinone and 10 percent inert ingredients.

Hexazinone is slightly toxic to mammals based on acute oral exposure in rats. Acute toxicity effects include pallor, salivation, nose bleeds, dyspnea, lethargy, tremors, and convulsions. These effects were only observed at lethal or near-lethal doses. Although hexazinone is a very slight skin irritant, it is classified as a severe eye irritant. No teratogenic or reproductive effects have been observed for hexazinone. Available evidence also indicates that hexazinone is noncarcinogenic and nonmutagenic. The herbicide is practically nontoxic to birds and fish and is relatively nontoxic to insects. Hexazinone is slightly toxic to aquatic invertebrates, however.

Microbial decomposition appears to occur. Photolysis occurs, volatization is negligible. Adsorption to soil is low. Mobility is high as its solubility in water. Soil half-life persistence is 30 to 180 days. See Table 3-6.

Imazapyr. Imazapyr is a broad-spectrum, nonselective herbicide used to control annual and perennial herbaceous plants, deciduous trees, vines, and brambles in noncropland situations. Registered uses include railroad, utility and pipeline rights-of-way, petroleum tank farms, utility plant sites, and fence rows. Imazapyr is readily absorbed by roots and foliage of plants and inhibits plant growth by affecting the biosynthetic pathway of aliphatic amino acids.

Pure imazapyr is a white-to-tan powder, with a slight acetic acid odor. Its melting point is 169° to 173° C (336° to 343° F) and is only slightly soluble in water. The formulation proposed for use on BLM lands, Arsenal™, is manufactured by American Cyanamid, and contains 27.6 percent imazapyr and 72.4 percent inert ingredients.

Based on acute oral exposures in rats, imazapyr is considered very slightly toxic to mammals. Imazapyr is slightly irritating to the eyes and skin. Available data indicate that imazapyr has no reproductive, teratogenic, or mutagenic effects. No evidence of carcinogenicity has been observed in preliminary oncogenicity studies, but further study is required to determine the herbicide's carcinogenic potential. The technical grade and the Arsenal™ formulation are practically nontoxic to birds and fish. Also, an aquatic invertebrate, the water flea, has been found to be insensitive to Arsenal™.

Microbial decomposition is not important, however, photolysis is significant. Adsorption to soil is strong, and as a result, leaching does not appear to be important. It is completely soluble in water. Soil half-life persistence of imazapyr acid is 90 to 712 days. See Table 3-6.

Mefluidide. Mefluidide suppresses vegetative growth and seedhead development of many plant species, including many turf grasses, grass and broadleaf weeds, and ornamental and nonornamental woody plants. Mefluidide is absorbed through the leaves and inhibits the growth and meristematic regions of affected plants.

Mefluidide is an odorless, colorless, crystalline solid. Embark™, the formulation proposed for use by BLM, is manufactured by the PBI/Gordon Corporation and contains 28 percent mefluidide and 72 percent inert ingredients.

Mefluidide is classified as slightly toxic to mammals. It is nonirritating to skin and causes minimal eye irritation. Oncogenicity and mutagenicity studies indicate that mefluidide is noncarcinogenic and nonmutagenic. For wildlife, mefluidide is of low toxicity to birds and is relatively nontoxic to fish and bees.

Microbial decomposition appears to occur. Photolysis may be important. Adsorption on soil is insignificant. Mobility is probably high. There is incomplete information on persistence although its persistence in soil has a half-life of 2 days. See Table 3-6.

Metsulfuron methyl. Metsulfuron methyl is an herbicide for selective broadleaf weed control in wheat, barley, and reduced-tillage fallow preceding wheat. In noncropland areas, metsulfuron methyl is used as a broad-spectrum herbicide for broadleaf weed and brush control. Metsulfuron methyl is absorbed by foliage and is a growth inhibitor.

Pure metsulfuron methyl is a white-to-pale-yellow solid with a faint, sweet odor. Its melting point is 158° C (316° F), and it is moderately soluble in water. Escort™, a formulation manufactured by Du Pont, contains 60 percent metsulfuron methyl and 40 percent inert ingredients and is proposed for use on BLM lands.

Metsulfuron methyl is classified as very slightly toxic to mammals. Although EPA has not evaluated the human carcinogenic potential of metsulfuron methyl, available data indicate that the herbicide is noncarcinogenic. Mutagenicity studies similarly indicate that metsulfuron methyl is nonmutagenic. Metsulfuron methyl is slightly toxic to birds and practically nontoxic to fish and aquatic invertebrates.

Degradation is through microbial processes and hydrolysis. Photolysis and volatilization are minor degradation processes. Soil half-life persistence is 14 to 180 days. See Table 3-6.

Picloram. Picloram is an herbicide used for general woody plant control and control of most annual and perennial broadleaf weeds. It also may be used to control broadleaf weeds in grass crops. Picloram is absorbed readily by foliage and roots and acts as an auxin-like, growth-inhibiting herbicide.

Picloram is a white powder, with a chlorine-like odor at room temperature. Chemical decomposition occurs before melting temperature is reached. Tordon™ and Grazon™ PC, manufactured by Dow Chemical, are proposed for use on BLM lands.

Based on acute oral exposures in rats, picloram is considered slightly toxic to mammals. It also is a slight eye and very slight skin irritant. Oncogenicity studies have been inconclusive but indicate that picloram may have carcinogenic potential. Consequently, picloram was assumed to be a carcinogen in the herbicide risk assessment conducted for this final EIS. EPA has requested the submission of additional studies for oncogenicity, as well as for teratology and reproduction. Mutagenicity studies, however, indicate that picloram is nonmutagenic. Picloram is slightly toxic to birds, relatively nontoxic to honey bees, and moderately to slightly toxic to aquatic organisms.

Microbial breakdown occurs slowly. Photolysis is an important breakdown process. Adsorption is low, mobility high, and solubility high. Soil half-life persistence of picloram salt is 20 to 277 days. See Table 3-6.

Simazine. Simazine is a widely used selective herbicide for controlling broadleaf and grass weeds in corn, citrus, deciduous fruits and nuts, olives, pineapple, sugar cane, and artichokes. It also is used as a nonselective herbicide for vegetation control in noncropland. Simazine is absorbed rapidly through the roots and inhibits photosynthesis.

Simazine is a white, odorless, crystalline solid with a melting point of 225° to 227° C (437° to 441° F). The formulations proposed for use on BLM lands are Princep™ 80W, Princep™ 4G, and Aquazine™, manufactured by Ciba-Geigy, and Simazine™ 80W, manufactured by the Drexel Chemical Company.

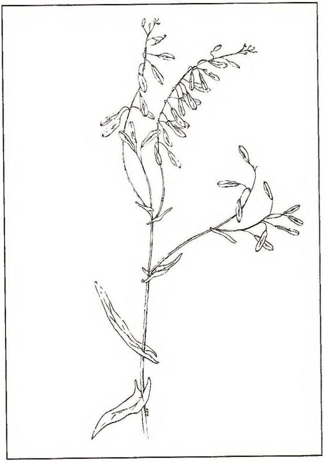
For mammals, simazine is classified as very slightly toxic during acute oral exposure and as moderately toxic for acute inhalation toxicity. The herbicide is slightly irritating to eyes and nonirritating to skin. No teratogenic or reproductive effects have been observed in rats. Based on a 2-year dietary oncogenicity study with rats, EPA has classified simazine as a possible human carcinogen. Thus, simazine was assumed to be carcinogenic in the herbicide risk assessment conducted for this final EIS. Mutagenicity studies indicate that, at worst, simazine poses only a slight mutagenic risk to humans. For wildlife, simazine is practically nontoxic to birds but is moderately to slightly toxic to fish and aquatic invertebrates.

Microbial breakdown is an important process. Adsorption is high on mulch and clay. Mobility is moderate, and its solubility is low at 84 ppm. Soil half-life persistence is 11 to 149 days. See Table 3-6. In ponds the average half-life is 30 days.

Sulfometuron Methyl. Sulfometuron methyl is used as a broad-spectrum herbicide for controlling annual and perennial grasses and broadleaf herbs on noncroplands. Sulfometuron methyl is absorbed easily by foliage and roots and inhibits plant growth.

Pure sulfometuron methyl is a white, odorless solid with a melting point of 203° to 205° C (397° to 401° F). Oust™, manufactured by Du Pont, is a dispersible granule containing 75 percent sulfometuron methyl and 25 percent inert ingredients. This formulation is proposed for use on BLM lands.

Sulfometuron methyl is very slightly toxic to mammals through acute oral exposure and slightly toxic through acute dermal exposure. It is slightly irritating to eyes and skin. No carcinogenic, mutagenic, or teratogenic effects of sulfometuron methyl have been observed in laboratory studies, but decreased reproductive success has been noticed in rats. The herbicide is very slightly toxic to birds, slightly toxic to aquatic organisms, and relatively nontoxic to bees.



Dyer's Woad

Microbial breakdown is significant. Photolysis and volatization are not important. Information on mobility is not available. Solubility is low at 300 ppm. Soil half-life persistence is 20 days. See Table 3-6.

Tebuthiuron. Tebuthiuron is a relatively nonselective, soil-activated herbicide. It has been registered in the United States since 1974 for controlling broadleaf weeds, grasses, and brush in noncrop areas and for spot treatment of woody brush on rangelands and pastures. The herbicide is absorbed readily through the roots of target plants and acts as a photosynthesis inhibitor.

Tebuthiuron is an odorless, colorless solid. The major formulations of tebuthiuron, manufactured by the Elanco Products Company, are Graslan™ and Spike™. Graslan™ and Spike™ are used predominantly on rangelands and noncropland areas.

Based on acute oral exposures to rats, tebuthiuron is classified as slightly toxic to mammals. However, no acute oral toxicity studies have been validated by EPA. Other data gaps exist for acute dermal exposure, skin and eye irritation, and teratology. Available data indicate that tebuthiuron is nonmutagenic and noncarcinogenic. Tebuthiuron is slightly toxic to birds and of relatively low toxicity for bees and other terrestrial invertebrates. Also, this herbicide is practically nontoxic to most fish and invertebrates and slightly toxic to other species.

Microbial breakdown may be important. Adsorption is high on clay and organic matter. Photolysis and volatization are not important. Mobility is considered moderate to high. Soil half-life persistence is 13 to 450 days. See Table 3-6.

Triclopyr. Triclopyr is an auxin-type selective herbicide effective against woody plants and broadleaf weeds. The herbicide is particularly effective against root-sprouting species, including ash and oaks, and is used for brush and weed control on rangelands, industrial sites, permanent grass pastures, and broadleaf and aquatic weed control in rice. However, most grass species are tolerant of triclopyr.

Pure triclopyr is an odorless, white solid. Commonly used formulations of triclopyr are Garlon 3A™ and Garlon 4™, manufactured by Dow Chemical. Garlon 3A™ is a water-soluble triethylamine salt formulation containing 3 pounds of triclopyr acid equivalent per gallon, while Garlon 4™ is an oil-soluble, water-emulsifiable butoxyethyl ester formulation with 4 pounds of triclopyr acid equivalent per gallon. In addition, Grazon ET™, another Dow product, is also proposed for use on BLM lands.

Based on acute oral exposures in rats, technical triclopyr is classified as slightly toxic. However, triclopyr is moderately toxic to guinea pigs. The technical grade is a moderate eye irritant and a slight skin irritant. The Garlon 3A™ and Garlon 4™ formulations also are slightly toxic to mammals, but Garlon 3A™ causes slight to moderate skin irritation and moderate to severe eye irritation. Laboratory data indicate that triclopyr is noncarcinogenic and nonmutagenic. The technical grade and the formulations are slightly toxic to birds and the technical is relatively nontoxic to insects. Various formulations of triclopyr have widely varying toxicities for aquatic organisms; the Garlon 3A™-butoxyethyl ester form is highly toxic to fish, while the technical and Garlon 3A™-triethylamine salt are practically nontoxic.

Microbial breakdown appears to be important. Loss from photolysis is important. Adsorption is not strong and mobility is moderate to high. Solubility is 430 ppm in water. Soil half-life persistence of triclopyr ester is 30 to 90 days. See Table 3-6.

INERT INGREDIENTS

Inert ingredients are chemicals used with the active ingredient in preparing a formulation of an herbicide. Inert ingredients are used to provide a carrier for the active ingredient that facilitates the effective application of the herbicide. Inerts are not intended to supplement an herbicide's toxic properties.

EPA's Office of Pesticides and Toxic Substances has identified about 1,200 inert ingredients that are now used in approved pesticides and has reviewed the existing evidence concerning the toxicity of these inerts, including laboratory toxicity data, epidemiological data, and structure/activity relationships. Of particular concern in reviewing the inerts was their potential for causing chronic human health effects.

Because EPA normally classifies inert ingredients as "Confidential Business Information," the agency does not have to release information on them to the public under the Freedom of Information Act (see also 40 CFR 1506.(a)). Nonetheless, BLM investigated the status of the inerts in the formulations proposed for use in this final EIS by surveying the manufacturers. The Bureau found that none of the herbicides proposed for use, with two exceptions, contain any inert ingredients appearing on either List 1 or List 2. The exceptions are Esteron 99™ and Garlon 4™, which contain a petroleum distillate of high priority for testing. Accordingly, a risk analysis has been conducted on the human health risk from exposure to the petroleum distillate in Esteron 99™ and Garlon 4™.

See Appendix M for a listing of formulations that have been investigated to insure that they contain no inerts on Lists 1 and 2, except as noted above.

MITIGATION

The purpose of this section is to describe protective measures that are being applied on a regular basis for the various types of vegetation treatment. Special mitigation procedures are identified and then required by the authorized BLM officer (manager) as part of the site-specific analysis and appropriate documentation at the time each individual project is considered. This information can be incorporated as appropriate by the local BLM field office, with additional public involvement before BLM takes any treatment action. In addition, each site-specific analysis will include a human health risk management plan for each proposed treatment project, and each treatment proposal would be designed in accordance with BLM and State weed control guides or handbooks that provide up-to-date directions on herbicide application rates, proper mixtures, safety procedures, and important restrictions that meet State and EPA standards.

PROJECT DESIGN FEATURES

Project design features are intended to ensure the proper and safe implementation of treatment methods. This includes proper and safe application of herbicides on BLM lands in the program States as required by Federal, State, and regional procedures. Federal and State laws and regulations set minimum standards to follow when applying herbicides on Government-owned forests and rangelands. Each regional and district office may develop additional restrictions and precautions.

Disposal of hazardous waste from these projects will be minimized in a number of methods. Because a large portion of the pesticide use in BLM is under contract, all contracts will specify that all containers be removed from BLM-administered lands and disposal of these containers under EPA guidelines is the responsibility of the contractor. Where BLM is the applicator, only the amount of pesticide needed for the project is purchased and stored. Guidelines for storage is provided in BLM Manual Section 9011. Excess pesticides should be used for the intended use and any rinsate from pesticide storage cans and equipment should be applied to the project site. Further, guidelines for storage, transportation, and disposal is provided in BLM Section 9011 Handbook, and on the label for specific pesticides.

Some specific examples of project design features include the following:

Herbicide Treatments

(1) Application operations will typically be suspended when any of the following conditions exist on the treatment area:

   (a) Wind velocity exceeds 6 miles per hour for the application of liquids or 15 miles per hour for the application of granular herbicides, or as specified on the label (whichever is less).

   (b) Snow or ice covers the target foliage.

   (c) Precipitation is occurring or is imminent.

   (d) Fog significantly reduces visibility.

   (e) Air turbulence (for example, thermal updrafts) is sufficient to affect the normal chemical distribution pattern.

(2) During air operations, a radio network will be maintained to link all parts of the project.

(3) Equipment will be designed to deliver a median droplet diameter of 200 to 800 microns. This droplet size is large enough to avoid excessive drift while providing adequate coverage of target vegetation.

(4) Individuals involved in the herbicide handling or application will be instructed on the safety plan and spill procedures.

Other general mitigation that pertain to treatment methods and alternatives described in this final EIS are as follows:

(1) Herbicides with high health and safety risks would be limited in use. Other herbicides and other types of treatment that are viable alternatives would be used. Whenever possible, less than maximum application rates will be used that will still meet the needs to effectively control or eradicate target species.

(2) Select herbicides with minimum toxicity to the significantly affected fish and wildlife species in the potentially affected treatment area, while maintaining adequate toxicity to the target plant species.

(3) A preventative maintenance program will be incorporated as part of each project treatment proposal that would help guard against re-encroachment of undesired plant or shrub species.

(4) Protective buffer zones will be provided along important riparian habitat not designed to be treated and along streams, rivers, lakes, wetlands, and xeroriparian areas along important dry water courses.

(5) In situations when control of the location of aerial spray is critical, as in buffers to riparian and aquatic areas, and when control of the configuration of the treatment area is necessary for the success of the project (e.g. spraying around meadows and in sagebrush when sage grouse habitat could be impacted), spraying should be accomplished by helicopter.

(6) When significant impacts to fish from application of herbicides are likely, the following mitigation is recommended: a) Application will avoid time periods when fish are in life stages most sensitive to herbicide impacts (egg, larvae, and smolt) in waters adjacent to the application areas; b) Emphasize spot spraying or other methods of treatment near streams, especially important fisheries; c) Reduce frequency and rates of application of herbicides by timing application to the most vulnerable phenological events of the target plant species; d) Select herbicides with minimum toxicity to potentially affected fish and other aquatic wildlife species in the treatment area, or area potentially affected, while maintaining adequate toxicity to the target plant species; e) Minimize use of chemicals that might have adverse impacts on aquatic habitats; f) Establish contingencies through the Safety Plan for immediate reaction and mitigation in the case of accidental spills, unplanned drift, or other serious environmental accidents impacting important streams and water bodies.

(7) Periods of treatment should avoid the bird nesting season and other critical seasons when loss of cover would be critical to wildlife; e.g. during critical reproductive periods and prior to severe winter weather conditions. Application of diesel fuel as a carrier of herbicides, to bird eggs, and young of any wildlife species, should be avoided.

(8) Prior to herbicide applications, any managed apiaries (honey bee colonies) in the vicinity will be notified in advance to allow time for removal or other protection of the hives.

(9) Precautions will be taken to assure that equipment used for storage, transport, and mixing or application will not leak into water or soil creating a contamination hazard.

(10) Helicopter ferrying routes between the staging area and spray area will be planned to avoid flights over aquatic systems and human habitation.

(12) Monitoring of mitigation effectiveness will be conducted.

(13) Areas with high risk for ground water contamination would not likely be included to receive herbicide treatments, particularly if those areas serve as domestic water sources. All areas considered for herbicide application would be evaluated in terms of the EPA's DRASTIC index that estimates the potential vulnerability to ground water contamination. The DRASTIC index uses site factors including soil permeability, underlying geologic characteristics, depth to water, and recharge potential. Generally, an area with a rating above 100 is considered to be of moderate to high risk. Care should be taken to make sure the DRASTIC system is applied properly at the site-treatment level.

If it is determined that high risk areas require herbicide treatment, those areas would be further evaluated to determine the conditions that would allow herbicide application without loss of the herbicide from the root zone. Such analysis (Carsel et al. 1984) would require information on the herbicides solubility, mobility, speciation, and degradation factors. In addition, site recharge would be evaluated to determine areas that may have high recharge zones, such as those where small amounts of precipitation concentrate in a depression because of surface and subsurface runoff. High risk recharge zones would generally not be considered for herbicide treatment.

Project plans would generally include the use of applicable BMPs where they exist. State water quality regulators could review all vegetation treatment plans and environmental analyses.

(14) When application and timing of herbicide spraying could cause a hazard for human consumption of wild game taken by sport hunters, the spray area should be adequately posted to warn hunters of the potential hazard.

(15) When transporting herbicide mixes on forest roads within domestic/municipal, fish hatchery, or irrigation supply watersheds, tanker trucks will use a pilot vehicle. Tanker drivers shall know the Spill Incident Response Plan.

(16) Standards and guidelines in BLM Handbook Section 9011 (Pesticide Storage, Transportation, Spills, and Disposal) Section II will be met. This defines standards for storage facilities, posting and handling, accountability, and transportation. It covers spill prevention, planning, cleanup, and container disposal requirements.

Other Treatments

(1) Treatments such as tilling and chaining will be designed and landscaped to minimize the negative impacts on aesthetic values. In the case of

tree chainings, consideration will be given to salvaging the woodland products and then burning the remaining dead material in an effort to minimize the negative impact on the visual resource.

(2) Irregular boundaries for maximizing edge effect will be incorporated into all methods of treatment. Undisturbed islands of natural vegetation will be left, where appropriate, to minimize negative impacts to the wildlife community.

(3) Especially in the case of mechanical treatment, care will be taken to assure that excessive land slope, unfavorable soil conditions, etc. do not contribute to long-term accelerated erosion conditions. In most cases, treatments should be confined to the more gentle slopes and ideal soil conditions which will generally result in reduced soil erosion.

See Appendix J for references for further discussion of mitigation.

Special Precautions

Special provisions for treatments would be selected according to the scope of the action and the physical characteristics of the specific site. BLM manual sections and handbooks provide a variety of approved standards and special provisions for renewable resource improvements and treatments (BLM 1981a, 1985b, 1985c, 1987b). Periodically, BLM updates recommended proposals for pre- and post-treatments. There are other precautions taken in consideration of special status species, wilderness, and cultural resources, as described below.

Special Status Species

Federal policies and procedures for protecting endangered and threatened species of fish, wildlife, and plants were established by the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.) and regulations issued pursuant to the act. The purposes of the act are to provide mechanisms for the conservation of endangered and threatened species and the habitats upon which they depend, and to achieve the goals of international treaties and conventions related to endangered species. Under the act, the Secretary of the Interior is required to determine which species are endangered or threatened and to issue regulations for the protection of those species. If any species is determined by the U.S. Fish and Wildlife Service (FWS) to be endangered or threatened, any action that would jeopardize its continued existence would be in violation of the act.

Death Camas

Section 7 of the Endangered Species Act (ESA) (Public Law 97-304) specifically requires all Federal agencies to use their authorities in furtherance of ESA to (a) carry out programs for the conservation of listed species and (b) to ensure that no agency action is likely to jeopardize the continued existence of a listed species or adversely modify critical habitat. This is a nondiscretionary requirement pertaining to the actions of all Federal agencies. BLM policy and guidance establish that species proposed for Federal listing be managed at the same level of protection as listed species except that formal consultation is not required. However, Section 7 conference with U.S. Fish and Wildlife Service is required for "may affect" situations on proposed species (BLM Manual 8440). For Category 1 and 2 candidate species, the BLM shall carry out management consistent with the preservation of the species and their habitats and shall ensure that actions authorized, funded, or carried out do not contribute to the need to list any of these species as threatened or endangered (BLM Manual 6840).

The BLM will strive to maintain optimum habitats for endangered and threatened species on its lands. Approximately 5.5 million acres of BLM managed

lands provide habitat for species that have been listed as endangered or threatened by the FWS. In addition, BLM will consider species that have been declining in abundance—but have not been listed as endangered or threatened (candidate species)—when proposing land management practices. BLM anticipates the addition of 15 to 20 more special status species annually to the list of species that occur on BLM-administered lands because of a backlog at FWS. For a full listing of these special status species in the 13 Western States, see Appendix H.

BLM State Directors may designate sensitive species in cooperation with their respective State. These sensitive species must receive, at a minimum, the same level of protection as Federal candidate species (BLM Manual 6840). BLM shall carry out management for the conservation of State-list plants and animals. State laws protecting these species apply to all BLM programs and actions to the extent that they are consistent with FLPMA and other Federal laws. Where the State governments have designated species in categories that imply local rarity, endangerment, extirpation, or extinction, the State Directors will develop policies to help the State achieve their management objectives for those species (BLM Manual 6840).

Preserving existing habitats, restoring degraded habitats, and participating in recovery planning for these special status species are essential for protecting these populations. BLM is involved with both habitat management and wildlife management for special status species on its lands. Reintroduction programs on BLM-managed lands have been successful for many wildlife species, including the bighorn sheep, the pronghorn antelope, and the American peregrine falcon. Bighorn sheep now exist on a significant portion of their historic range as a result of these efforts (Fish and Wildlife 2000).

Because BLM is committed to mitigating adverse impacts on special status species, land management strategies will be studied on a site-specific basis to determine the effects, if any, on local habitats.

For example, many special status animal species are directly dependent on vegetation for habitat, and any change in the vegetation of a particular plant community is likely to affect the species associated with that community. Therefore, risks to special status animal species must be analyzed and documented before any site-specific action.

All BLM actions will be evaluated for potential impact to State and Federal species. If the evaluation indicates a "no affect" situation, the action may proceed. If the evaluation indicates a "may affect" situation (may affect includes both beneficial and adverse impacts) on a federally listed species and the adverse impacts cannot be eliminated, Section 7 consultation with the FWS must be conducted. BLM does not have the authority to make a "no affect" finding if a "may affect" situation exists. For federally proposed species, a Section 7 conference will be conducted. There are no legal requirements for Federal candidate species other than BLM policy for multiple-use management and to eliminate the need for listing. In general, BLM should be managing all of its programs for the conservation of endangered species to the extent that a jeopardy opinion need never be issued by the FWS or an individual State.

After beginning Section 7 consultation with the FWS on a federally listed species, BLM will not, in accordance with Section 7 of ESA, make any irreversible or irretrievable commitment of resources that would preclude the formulation and execution of a reasonable alternative to solve the conflict.

Wilderness

In wilderness areas, BLM's policy is to allow natural ecological processes to occur and be interfered with only in rare circumstances. BLM does not ordinarily treat vegetation in these areas unless, as in the case of noxious weeds, it is spreading within the wilderness area or to adjacent lands (BLM 1987e).

If vegetation control is found to be necessary in Wilderness Study Areas (WSA) and no effective alternative exists, BLM's policy is to limit its control program to small areas, limit the treatment method to manual or prescribed fire, and limit the area treated. Some actions can occur in WSAs that would not be allowed in wilderness areas, but BLM manages WSAs to avoid impairing their suitability for preservation as wilderness or affect their wilderness values (BLM 1983, 1988d).

Cultural Resources

The effects of BLM actions on cultural resources are assessed and mitigated through consultation among BLM, the Advisory Council on Historic Preservation, and State Historic Preservation Officers through the process defined in Section 106 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470), and implemented in 36 CFR 800. These legal mandates require BLM to consider the effects of its actions on historic properties through project-specific inventory to identify significant cultural properties (eligible for inclusion in the National Register of Historic Places) and avoid or mitigate possible direct and indirect impacts to them.

The American Indian Religious Freedom Act of 1979 directs Federal Agencies to ensure that Indian religious rights and freedoms are not unnecessarily disrupted by agency practices. As refined in court cases this means that agencies must obtain and con-

sider the views of Indian leaders when a proposed land use might conflict with traditional Indian religious beliefs or practices. Bureau manuals (BLM 1988e) will be followed in considering traditional beliefs, practices, or other traditional lifeway values.

Whenever evidence of historic or prehistoric occupation is likely to be effected during BLM activities. A cultural resources inventory is required on all areas to be subjected to ground-disturbing activities. This is conducted in the preplanning stage of a treatment, and the results are analyzed in the environmental analysis addressing the action (BLM 1988e).

Impacts to significant cultural properties will be avoided through treatment project redesign or mitigated through data recovery, recordation, monitoring or other measures developed for the specific treatment project. Whenever possible vegetation treatments will be modified to avoid effecting traditional lifeway values, however, it may not be possible to avoid or mitigate all impacts to Indian traditional religious beliefs or practices and other traditional lifeway values.

When cultural resources are discovered during vegetation treatment activities, nearby operations are immediately suspended and may resume only upon receipt of written authorization from the BLM-authorized officer.

Tansy Ragwort

SUMMARY OF IMPACTS BY ALTERNATIVE

A comparison of the impacts of the treatment program alternatives is presented in Table 1-9. Although these impacts are described in detail in Chapter 3, the table is provided to assist decision-makers and reviewers by concisely summarizing the major impacts.

IMPLEMENTATION

Monitoring

All projects would be monitored to ensure that treatments are conducted in accordance with BLM procedures (BLM 1984c, 1984d). Manual and mechanical treatments would be monitored at regular intervals to determine the quality and quantity of completed work. Prescribed burns and chemical treatments would be monitored in progress for compliance to proper application technique, burn prescriptions, and safety procedures. Effectiveness of mitigating measures identified in project-specific environmental documents will be monitored through periodic inspections. Air quality would be monitored where appropriate. Post-treatment monitoring is essential to determine whether treatment objectives have been met and if the treatment was successful. Such monitoring will vary in intensity, and in some cases may consist of nothing more than visual inspection.

In other cases, monitoring will continue for some years after treatment in order to evaluate the full measure of response. Many rangeland treatments would have studies established in them to monitor treatment effects on vegetation as well as on other resources such as wildlife or water quality, depending on treatment objectives and affected resource values.

Table 1-9

Summary of Impacts by Alternative

Resource Elements	Alternative 1 (Proposed action)	Alternative 2 (No Aerial Application of Herbicides)	Alternative 3 (No Use of Herbicides)	Alternative 4 (No Prescribed Burning)	Alternative 5 (Continue Present Management)
Vegetation	Overall effect would be to achieve desired plant communities on treated sites, create stratified age structure dynamics in some shrublands for wildlife habitat improvement, reduce hazardous fuel buildup, reclaim certain areas to native perennial vegetation, reduce populations and spread of noxious weeds, remove vegetation that was a potential hazard to recreationists, and maintain safe conditions in rights-of-ways and oil and gas facilities. Specific areas of some shrub-dominated rangeland communities would have higher production of herbaceous vegetation mixed with shrubs. Greatest number of options for treatment method allow greatest management flexibility.	Overall effect would be fewer areas on which desired plant community objectives were met in desired timeframes. Less acreage would be treated chemically than Alternative 1, but more acreage would be burned. Less management flexibility to select most appropriate and cost-effective treatment for rangeland situations, but smaller-scale treatments of oil and gas facilities, rights-of-ways, recreation areas, riparian areas, and most noxious weed infestations would not be greatly affected.	Overall effect would be fewer areas on which desired plant community objectives were met in desired timeframes than both Alternatives 1 and 2. Less management flexibility to select most appropriate and cost-effective method in all situations when vegetation treatment is proposed. Noxious weed control would be ineffective for species which had no biological control agents, making public lands an infestation source for adjacent lands under other ownership. Ineffectiveness of alternative treatments would create safety hazards to oil and gas facility sites and rights-of-way, and some recreation sites. Saltcedar control in riparian areas would be much less effective than under Alternative 1. High use of prescribed fire would continue to affect both target and nontarget species.	Overall effect would be fewer areas on which desired plant community objectives were met in desired timeframes than both Alternatives 1 and 2. Less management flexibility to select most appropriate and cost-effective method in all rangeland situations. Highest level of chemical use of all alternatives. Higher probability of catastrophic wildfire. Long-term undesirable effects in all vegetation analysis regions where fire has played a historic ecological role.	Overall effect would be fewer areas on which desired plant community objectives were met in desired timeframes than Alternative 1. Noxious weed control would be less effective than Alternative 1, but more effective than Alternative 3. Less acreage treated chemically than any alternative except Alternative 3.
Climate and Air Quality	Moderate, short-term increases in smoke, exhaust, and drift expected; however, standards would not be violated. Temporary, localized noise from aircraft and equipment.	Suspension of aerial operations reduces risk of herbicide drift; increase in visible smoke and particulates with increase in prescribed burning. Standards would not be violated.	Elimination of drift from chemical treatment. Impacts of visible smoke and particulates from prescribed burning greater than Alternatives 1 and 2. Standards would not be violated.	Elimination of prescribed burning increases chemical treatment and subsequent herbicide drift. Smoke from wildfires would increase. Standards would not be violated.	Slightly less impact than Alternative 1. Standards would not be violated.

Table 1-9 (Continued)

Summary of Impacts by Alternative

Resource Elements	Alternative 1 (Proposed action)	Alternative 2 (No Aerial Application of Herbicides)	Alternative 3 (No Use of Herbicides)	Alternative 4 (No Prescribed Burning)	Alternative 5 (Continue Present Management)
Geology and Topography	No impacts to geology and topography.	No impacts. Same as Alternative 1.	No impacts. Same as Alternative 1.	No impacts. Same as Alternative 1.	No impacts. Same as Alternative 1.
Soils	Short-term decreases in soil productivity and increases in erosion; long-term stabilization.	More erosion likely than under Alternatives 1, 4, and 5.	More erosion likely than under Alternatives 1, 2, and 4.	Slightly more erosion likely from mechanical treatments than under Alternative 1. Fewer overall impacts due to no burning.	Less impacts on short-term soil-productivity losses and increased soil erosion than Alternative 1.
Aquatic Resources	Short-term erosion and sedimentation from mechanical and prescribed burning treatment. Unlikely that any significant amount of herbicides will be introduced into streams or ground water.	About the same as Alternative 1; more noticeable short-term impacts to perennial and ephemeral streams due to the greater amount of mechanical treatment. However, this alternative would reduce the possibility of herbicides drifting onto surface water.	Control of target species would have highest short-term erosion impacts to water resources due to the greater amount of mechanical treatments. Totally eliminates the potential risk of surface and ground water contamination from herbicides.	About the same as Alternative 1; more noticeable impacts to water resources due to the greater amount of mechanical treatments. More impact from herbicide drift than any alternative.	Overall impacts due to all treatments would be less than Alternative 1, because total acreage treated is likely to be less.
Fish and Wildlife	Potential impacts to fisheries or riparian resources, but none with proper mitigation. Greatest potential impacts, both beneficial and adverse, to terrestrial wildlife resources and habitats of all alternatives. Largest acreages of current existing habitats would be disturbed. Both short-term and long-term impacts to individual wildlife species would occur.	Less potential for adverse impacts to fisheries or riparian resources than Alternative 1. No potential for adverse impacts from aerial application of herbicides, some potential remains from ground applications. More competition from noxious weeds. Best ratio of high potential for beneficial impacts, with a reduced potential for adverse impacts, of all alternatives.	No impacts to fisheries and riparian from herbicides, but potential is increased for impacts from escaped prescribed burns. All herbicide impacts eliminated. Some beneficial projects eliminated. Fewer acres of current habitats disturbed than in Alternatives 1, 2, and 4. Most adverse impacts from uncontrolled noxious weeds. The only effective tool for saltcedar control is eliminated.	Greatest potential adverse impacts and least beneficial impacts to fisheries and riparian resources. Most practical and cost efficient vegetation and habitat treatment and clean-up tool eliminated. Greatest potential adverse impacts from herbicide application. Least beneficial alternative to the wildlife resource.	Fewest acres treated of all alternatives. Least potential adverse impacts. Limited opportunity for beneficial impacts from well designed habitat improvement projects.

Table 1-9 (Continued)

Summary of Impacts by Alternative

Resource Elements	Alternative 1 (Proposed action)	Alternative 2 (No Aerial Application of Herbicides)	Alternative 3 (No Use of Herbicides)	Alternative 4 (No Prescribed Burning)	Alternative 5 (Continue Present Management)
Cultural Resources	Low probability of site damage because fewer acres are treated than with manual or mechanical methods. Possibility of chemical contamination of sites.	Slightly higher probability of damage to sites than Alternatives 1, 4, and 5.	Higher probability of damage to sites than Alternatives 1, 2, and 4.	Slightly higher probability of damage to sites than Alternative 1.	Less impacts than Alternative 1.
Recreation and Visual Resources	Short-term impact to quality of scenic values. Recreation areas infested with noxious weeds and poisonous plants would benefit from decreased visitor exposure to adverse effects from these species.	About the same impacts as under Alternative 1. Slightly increased risk of recreational exposure to noxious weeds and poisonous plants than under Alternatives 1 and 4.	Visual impact is about the same as under Alternative 1. More untreated acres than under Alternatives 1, 2, and 4. Spread of noxious weeds and poisonous plants would increase exposure of recreationalists to detrimental effects if nonchemical measures fail to control these species.	About the same as under Alternative 1. Increases use of other treatment methods that can result in negative effects to these resources on some sites.	Slightly less impacts than under Alternative 1, but less control of poisonous plants at recreation sites.
Livestock	Livestock will benefit from positive impacts, particularly increases in available forage. Livestock not likely to be adversely affected.	About the same as Alternative 1.	Some noxious weeds and toxic plants would not be controlled, thereby reducing the quality of livestock forage.	Significant reduction in forage on sites where burning is the most desirable treatment method.	Same as Alternative 1, but lower forage production.
Wild Horses and Burros	Wild horses and burros may benefit from improved vegetation diversity and reduction in unpalatable species.	About the same as Alternative 1.	Some noxious weeds and toxic plants would not be controlled and could reduce overall quality of forage.	Possible significant reduction in available forage.	Same as Alternative 1, but lower forage production.
Special Status Species	Site-specific analysis and consultation will ensure that no special status species are affected.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Wilderness and Special Areas	Undesirable vegetation in wilderness areas and WSAs may be controlled, improving competition among native plants in the natural ecosystem.	About the same impacts as under Alternative 1.	Impacts would be the same as under Alternative 1 except when nonchemical measures do not sufficiently control noxious weeds.	Eliminates closest natural treatment method where others are prohibited.	Slightly less impacts than under Alternative 1.

Table 1-9 (Continued)

Summary of Impacts by Alternative

Resource Elements	Alternative 1 (Proposed action)	Alternative 2 (No Aerial Application of Herbicides)	Alternative 3 (No Use of Herbicides)	Alternative 4 (No Prescribed Burning)	Alternative 5 (Continue Present Management)
Human Health and Safety	Public could be affected by amitrole. Workers may be affected by a number of herbicides. Minor risk to workers from manual and mechanical methods and prescribed burning. Smoke may affect sensitive members of the public. However, human health would benefit from treatment of noxious weeds and poisonous plants that adversely affect humans.	Hazards of manual, mechanical, and prescribed burning treatment methods would increase compared to Alternative 1. Less likelihood of adverse herbicide-related impacts. More untreated acreage than under Alternative 1 increases possibility of adverse effects of noxious weeds and poisonous plants.	More potential for adverse impacts from manual, mechanical, and prescribed burning than under Alternatives 1 and 2 because more acres are treated with these methods. No risk of hazards from chemical treatment. Less control of weeds hazardous to human health than in Alternatives 1, 2, and 4.	Risk of adverse effects of manual or chemical treatment greater than under Alternatives 1, 2, and 3. Slightly greater potential for impacts from mechanical treatment than Alternative 1.	Less impacts than under Alternative 1.
Social and Economic	Lower per-acre treatment cost than Alternatives 2, 3, or 4. Any increase in employment would be insignificant; the number of new jobs would be greater than Alternative 4 but less than Alternatives 2 or 3.	Higher per-acre treatment cost than Alternatives 1, 3, and 5. Any increase in employment would be insignificant; however, the number of new jobs would be greatest under this alternative and Alternative 3.	Higher per-acre treatment cost than Alternatives 1 and 5. Any increase in employment would be insignificant; however, the number of new jobs would be greatest under this alternative and Alternative 2. More socially desirable to some populations.	Higher per-acre treatment cost than all other alternatives. Any increase in employment would be insignificant; fewer new jobs would be expected under this alternative than under Alternatives 1, 2, and 3. Eliminates a more favorable treatment tool to some.	Lowest per-acre treatment cost. No new employment.

Requirements for Further Environmental Analysis

This FEIS is a programmatic statement describing the impacts of treating vegetation on BLM-administered lands in 13 Western States. Site-specific environmental analyses and documentation (including application of categorical exclusions where appropriate) on proposed vegetation control plans may be prepared on an individual project level at the district or resource area level in accordance with vegetation mangement objectives established in the land-use planning process. During site-specific analysis and documentation, public involvement will occur in accordance with the CEQ Regulations for implementing NEPA.

Interdisciplinary impact analyses will be based on this and other applicable EISs, including those for land-use plans, timber management programs, and grazing management programs. If later analysis finds a potential for significant impacts not already described in an existing EIS, a supplement or another EIS may be required.

INTERRELATIONSHIPS

BLM coordinates its weed and undesirable plant treatment activities with actions of related Federal and State agencies responsible for resource management and with adjacent landowners and managers. This section briefly describes major interrelationships that would be involved in a vegetation treatment program.

Other Federal Entities

BLM coordinates specific projects and programs with other land management agencies, such as the U.S. Fish and Wildlife Service, the National Park Service, and Soil Conservation Service when proposed actions may affect areas adjacent to resources managed by these agencies.

EPA

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended (7 U.S.C. 136 et seq.), establishes procedures for the registration, classification, and regulation of all pesticides. EPA is responsible for implementing FIFRA; primary enforcement responsibilities for use-related violations are assigned to States with approved programs.

Before any pesticide may be sold legally, it must be registered by EPA. EPA may classify a pesticide for unrestricted use if it determines that the pesticide is not likely to cause unreasonable adverse effects on applicators or the environment. EPA's determinations are based on research data supplied by the applicant for registration. States may classify pesticides for restricted use (which means they may be applied only by or under the direct supervision of a certified applicator or in accordance with other restrictions), even though EPA may not have done so. All the herbicides considered in this risk assessment are registered with EPA, and their label rates, uses, and handling instructions must be complied with according to Federal law.

BLM actions also will comply with other environmental legislation, such as the Clean Air Act, as amended (42 U.S.C. 1857 et seq.), the Clean Water Act, and the Safe Drinking Water Act (42 U.S.C. 300(f) et seq.). The Clean Air Act sets national primary and secondary ambient air quality standards, requires that specific emission increases be evaluated to prevent a significant deterioration in air quality, and provides EPA with authority to set national standards for performance of new stationary sources of air pollutants and standards for emissions of hazardous air pollutants. The Clean Water Act requires all branches of the Federal Government involved in an activity that may result in a point source discharge or runoff of pollutants to water to comply with applicable Federal, State, interstate, and local requirements concerning the control and abatement of water pollution. The Safe Drinking Water Act allows EPA to designate any aquifer that serves as the principal source of drinking water for an area as a "sole source" aquifer. Federal agencies are prevented from granting assistance to any project that may contaminate such an aquifer and thus create a significant health hazard.

U.S. Fish and Wildlife Service

Federal policies and procedures for protecting endangered and threatened species of fish, wildlife, and plants were established by the Endangered Species Act of 1973, the Migratory Bird Treaty Act (16 U.S.C. 703-711), as amended, and the Fish and Wildlife Conservation Act of 1980 (16 U.S.C. 2901 et seq.). BLM vegetation treatment activities would be conducted in accordance within the guidelines established in these acts.

Section 7 of the Endangered Species Act requires Federal agencies to consult with the U.S. Fish and Wildlife Service or the National Marine Fisheries Service to ensure that any action that they authorize, fund, or carry out is not likely to jeopardize the continued survival of a listed species or result in the

adverse modification or destruction of its critical habitat (16 U.S.C. 1536 (a)(2)). In addition, the act requires that if species proposed for listing are likely to be jeopardized, a conference must be held with the U.S. Fish and Wildlife Service. This consultation may result in modification or abandonment of an action.

Consultations with the U.S. Fish and Wildlife Service and State agencies are encouraged by the Migratory Bird Treaty Act, if project activities could directly or indirectly harm migratory birds. If the U.S. Fish and Wildlife Service determines that migratory birds could be harmed, a site-specific assessment and mitigation would be developed to prevent harm to these species.

The Fish and Wildlife Conservation Act encourages Federal agencies to conserve and promote conservation of nongame fish and wildlife and their habitats to the maximum extent possible within each agency's statutory responsibilities.

National Park Service

The National Park Service administers national parks, monuments, and recreation areas to conserve the scenery, natural objects, and wildlife (16 U.S.C. 1). The National Park Service also administers the Nationwide Rivers Inventory as provided for in the Wild and Scenic Rivers Act of 1968 (16 U.S.C. 1271 et seq.). BLM will consult with the National Park Service if vegetation treatment actions are proposed on BLM lands adjoining land or rivers administered by the National Park Service.

Advisory Council on Historic Preservation (ACHP)

Section 106 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470) requires Federal agencies to consult with the ACHP in order to take into account the effects of Federal undertakings on historic properties. The views of the ACHP relative to historic resources are considered in project specific consultation documents as defined at 36 CFR 800 and in state specific programmatic agreements.

Native Americans

The American Indian Religious Freedom Act (42 U.S.C. 1996) provides for the protection and preservation of the rights of the American Indians to express and exercise tribal religious beliefs. Sites identified or suspected to be sacred to one or more tribes could be present on or adjacent to proposed treatment sites. Tribal governments will be consulted to determine whether the treatment area is of religious significance.

The views of Tribal governments relative to an area's traditional religious or cultural significance will be considered in project specific consultation documents as defined at 36 CFR 800 and in state specific programmatic agreements.

State and Local Governments

BLM's vegetation treatments would be conducted in accordance with applicable State and local government regulations, including the Sikes Act (16 U.S.C. 670 et seq.), as amended, the Federal Land Policy and Management Act (FLPMA), and the National Historic Preservation act of 1966 (NHPA).

The Sikes Act authorizes USDI, in cooperation with the State agencies responsible for the administration of fish and game laws, to plan, develop, maintain, and coordinate programs for the conservation and rehabilitation of wildlife, fish, and game on public lands within its jurisdiction. The plans must be consistent with any overall land-use and management plans for the lands involved and could include specific habitat improvement projects and related activities and adequate protection for species of fish, wildlife, and plants considered endangered or threatened.

The FLPMA (Section 202 (c)(9)) requires BLM to develop resource management programs consistent with those of State and local governments to the extent that such BLM programs also are consistent with Federal laws and regulations. The act also requires BLM to provide for compliance with applicable pollution control laws, including State and Federal air and water pollution standards or implementation plans.

Section 106 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470) requires Federal agencies to consult with State Historic Preservation Officers (SHPOs) and local governments in order to take into account the effects of Federal undertakings on historic properties. The views of the SHPO and affected local governments relative to historic properties are considered in project specific consultation documents as defined at 36 CFR 800 and in state specific programmatic agreements.

State and county weed control laws place responsibility for noxious weed control on individual landowners, including the Federal Government. Permittees and grantees operating within rights-of-way on BLM-administered land are required to comply with USDI herbicide-use regulations.

BLM also must coordinate with appropriate State agencies in management of State-listed plant and animal species when a State has formally made such designations.

Private Landowners

Private landowners are highly interested in BLM operations near their land, and BLM strives to keep these landowners informed about its vegetation treatment operations through coordination, cooperation, and consultation. Before preparing environmental documents at the State, district, or resource area level, BLM invites interested landowners to comment on proposed programs.

Limitations of This Final EIS

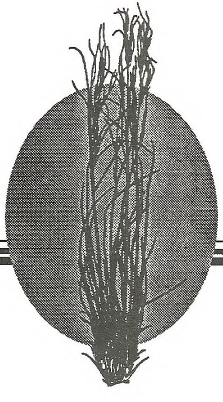
This EIS is a programmatic document that addresses environmental impacts at a fairly general level because of the broad land area over which those impacts might occur. Impacts at particular vegetation treatment sites may be assessed in environmental analyses tiered to this document, but those impacts should be no more severe than the most severe impacts discussed in this document.

The analyses of impact in this study are based on the most recent information available, particularly in the areas of mechanical treatments, prescribed burning, and herbicide effects on the vegetation, soils, and wildlife of major rangeland plant communities. The descriptions of mechanical, prescribed fire, and herbicide treatment impacts on soils, vegetation, and wildlife were prepared after a comprehensive review of the literature. Chapter 3, Environmental Consequences, presents considerable detail in these areas, but the level of detail was considered appropriate because the program is so broad in scope and the document needs to serve the requirements of the field people preparing the environmental analyses.

The human health and nontarget species herbicide risk assessment was based on the most recent available information concerning herbicide toxicity and environmental fate properties. The analysis was designed to consider a wide range of possible exposures and the resultant effects those exposures might cause, so it includes typical and worst case scenarios that involve routine applications and accidents. The doses that members of the public actually receive are not likely to be as high as most of the doses estimated in this analysis; in fact, in most herbicide applications on these remote sites, no member of the public is likely to be exposed at all.

Chapter 2

Affected Environment



CHAPTER 2

AFFECTED ENVIRONMENT

GENERAL DESCRIPTION

Part of the land administered by the Bureau of Land Management (BLM) in the 13 EIS States would be affected by the proposed vegetation treatment program (Figure 2-1). The more extensive areas include large, contiguous sections of the grasslands and savannas of the Great Plains, and the desert grasslands and shrublands of the Great Basin and Southwestern United States. BLM-administered lands constitute approximately 20 percent of the total area of the 13 States covered by this EIS, or about 158 million acres (Table 2-1). Of each State's total land area, the greatest proportion of BLM-administered lands are in Nevada, Utah, and Wyoming, with 69, 42, and 30 percent, respectively. North Dakota and Oklahoma have the lowest proportion, with 0.2 and 0.007 percent of their total land area under BLM jurisdiction (BLM 1988).

The natural environments and cultural characteristics of BLM-administered land and adjacent lands vary widely across the 13 States. Physical characteristics, such as climate and ground-water supplies, and biological parameters, such as plant productivity and the presence of special status species, differ markedly. Because of these differences, the impacts of each alternative BLM vegetation treatment program are likely to differ from one area to another. The BLM lands have been divided into eight regions for analysis (Figure 2-2), based primarily on the dominant plant species according to the classification system of Garrison et al. 1977. The dominant plant species were considered the most appropriate basis for partitioning the BLM lands because they are characteristic of broad areas of the West; reflect the soils, climate, and past land-use practices; and would most immediately reflect the results of vegetation treatment. The analysis regions include (1) sagebrush, (2) desert shrub, (3) southwestern shrub-steppe, (4) chaparral-mountain shrub, (5) pinyon-juniper, (6) plains grassland, (7) mountain/plateau grassland, and (8) coniferous/deciduous forest. Riparian areas are located within these regions and will be addressed where appropriate.

The sagebrush analysis region occupies the largest contiguous area of public lands and constitutes 31 percent of the EIS program area. The desert shrub and plains grassland areas also are relatively contiguous regions and compose 19 and 10 percent of the

Table 2-1

Acreage of BLM-Administered Lands and Percentage of State, 1987

State	Total Acreage of BLM Land	Total Acreage of State	Percentage of Land Managed by BLM
Arizona	12,285,326	72,688,000	16.9
Colorado	8,288,840	66,485,760	12.5
Idaho	11,953,795	52,933,120	22.6
Montana	8,920,710	93,271,040	9.6
Nevada	48,714,404	70,264,320	69.3
New Mexico	12,855,255	77,766,400	16.5
North Dakota	67,331	44,452,480	0.2
Oklahoma	3,026	44,087,680	0.01
Oregon[1]	13,539,906	61,598,720	22.0
South Dakota	279,473	48,881,920	0.6
Utah	22,129,277	52,696,960	42.0
Washington	311,292	42,693,760	0.7
Wyoming	18,412,451	62,343,040	29.5
Total	**157,761,086**	**790,163,200**	**20.0**

[1] Excludes 2,148,877 acres of BLM-administered land in western Oregon outside the study area.

Source: U.S. Department of the Interior, Bureau of Land Management 1988.

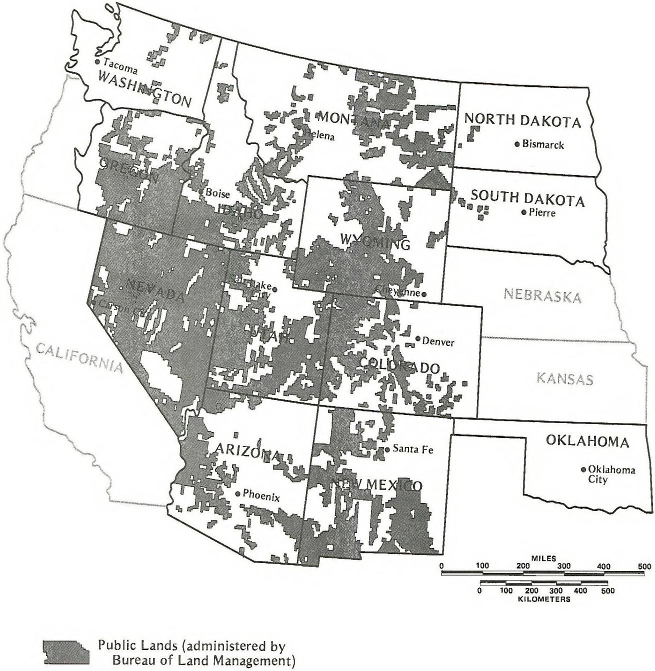


Figure 2-1
Bureau of Land Management Lands in the Study Area

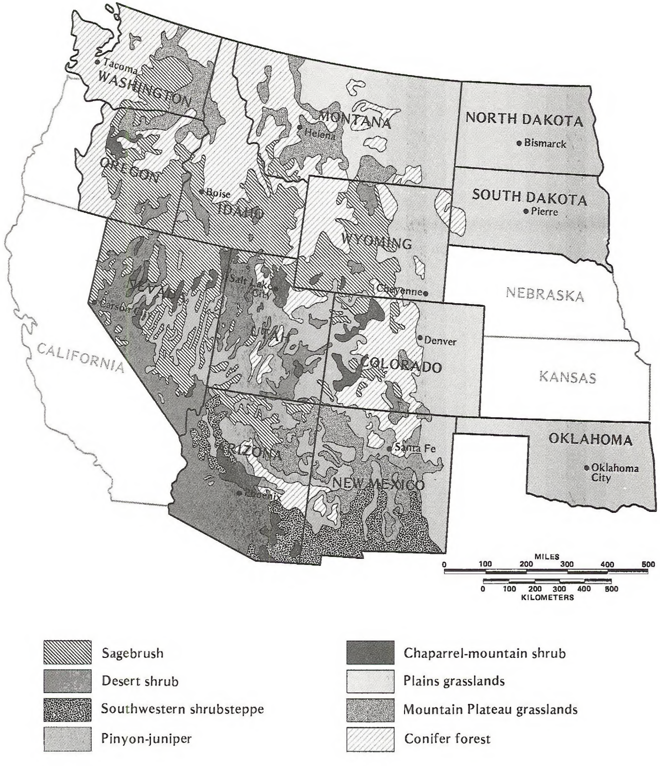


Figure 2-2
Vegetation Analysis Regions of the States in the Study Area

BLM program area, respectively. The southwestern shrubsteppe and mountain/plateau grassland areas are discontinuous regions and account for only 8 and 6 percent of the BLM program area, respectively. Pinyon-juniper, coniferous/deciduous, and chaparral-mountain shrub forests are confined to areas of higher elevation and constitute 17, 5, and 4 percent of the program lands.

This chapter describes the potentially affected environment of the 13 Western States in the EIS program area for the following resource elements: (1) vegetation, (2) climate and air quality, (3) geology and topography, (4) soils, (5) aquatic resources, (6) fish and wildlife, (7) cultural resources, (8) recreation and visual resources, (9) livestock, (10) wild horses and burros, (11) special status species (12) wilderness and special areas, (13) human health and safety, and (14) social and economic resources.

Where applicable, resources will be addressed by the eight analysis regions; some resources are more effectively discussed on a regional basis. The description of potentially affected environmental elements will emphasize rangeland resources because 85 percent of the area projected for vegetation treatment under the proposed action is characterized by rangeland vegetation.

ANALYSIS REGION DESCRIPTIONS

Vegetation

Plant communities are characterized by continual change (Zwolinski 1990). Vegetation communities are dynamic, and change through time and space occurs universally (Miles 1979; Patterson 1986). Change can be readily observable, as when one plant community replaces another through the process of plant succession. Such change occurs because of differences in establishment, growth and survival rates of plants, competitive ability of different species, and species longevity (Miles 1979). Changes can also be subtle, such as changes in the proportion and production of individual species on a site, and the establishment or death of individual plants. Evidence for change in vegetation can be found by direct observation over time, historical evidence, preserved biological evidence such as pollen and macrofossils in ancient packrat middens, and study of vegetation development on similar sites (Miles 1979; Smeins 1983).

Vegetation has undergone periodic, gross disturbance throughout most of evolutionary time (Miles 1979). For example, forest fires may have been common in the Tertiary period, beginning 70 million years ago, during the time of the evolution of most of the plant species currently present on earth (Harris 1958). The pattern of vegetative communities has fluctuated widely in the last 10 to 12,000 years, since the melting of the continental glaciers. During the post-glacial period, climate has been both notably warmer and cooler than it is at present. The boundary of forest and shrub/grassland has fluctuated accordingly (Mehringer and Wigand 1987), as well as those of other drier site plant communities. Only a weak stability was achieved in some semiarid pristine systems in the west (West 1985), and some may have been remnants of previously more favorable climatic conditions (Smeins 1983). A trend toward greater aridity, with the associated increase of many xerophytic woody plants, may have already been in existence. When European man arrived on the rangelands of western North America he observed ecosystems that were in a state of flux, although he often interpreted them as static phenomena (Smeins 1983).

Prior to European settlement, fire was the most common influence on the landscape in the intermountain west (Gruell 1983), and in much of the southwest (Wright 1990). In drier parts of the west, however, the significance of fire effects on vegetation can be difficult to separate from the effects of drought (Wright 1990). The break-up and reduction of fuels caused by grazing and cultivation that came with European settlement, and then the introduction of organized fire suppression, have caused a drastic decrease in fire occurrence and size (Gruell 1983; Swetnam 1990). With the omission of fire as a dominant ecological factor on many sites has come significant changes in vegetation. Successional changes that have occurred on some sites would unlikely have occurred in the pre-European environment, where frequent fires suppressed woody vegetation (Gruell 1983). Significant increase in density of woody species have occurred on some sites, as well as invasion of woody species onto sites where frequent fire used to preclude their dominance. Fire exclusion has had the most marked effect on ecotones, tension zones between two different community types. Naturally occurring fire was used to remove woody species that were sensitive to fire from communities that were more fire adapted.

In the western United States, factors which have affected vegetation development include climate (particularly drought), insects, diseases, wind, domestic livestock grazing, browsing by wild ungulates, and fire (Gruell 1983). It is important to understand the effects these factors have on the path of successional change in order to manage vegetation and habitat (West and Van Pelt 1987). Knowing the frequency and results of natural disturbances, such as fire, is necessary in order to understand the environmental pressures to which vegetation has

adapted and the kinds or amounts of vegetation a site can support, and thus the post treatment changes that are likely to occur. A land manager makes choices to encourage or retard plant succession to achieve the vegetation community that best meets multiple resource management objectives. In many of the arid and semiarid areas of the west, removal of livestock grazing pressure alone does not result in dramatic or rapid change of existing vegetation (Potter and Krenetsky 1967; Rice and Westoby 1978; Robertson 1947; Lommason 1948; Harniss and West 1973). Present day vegetation communities are a product of past human use and alteration of former disturbance regimes, but are subject to a multitude of present day demands and expectations. Manual, mechanical, or chemical treatments which mimic natural processes are selectively used to restore degraded plant communities or induce vegetation change to achieve a new situation which satisfies these demands and expectations.

Vegetation communities on BLM-administered lands in the EIS area reflect the climatic, geological, and topographic diversity of the Western United States. The descriptions of the vegetation analysis regions must be general, as each type encompasses site specific variations in species composition which may have been significantly modified by weather, fire, biotic factors, and human activities. Distribution and boundaries of these communities are further affected by local characteristics of elevation, latitude, slope, exposure, temperature inversions, and cold air drainages.

The most diverse vegetation communities, and the most complex to summarize, are the riparian communities. Riparian communities are not controlled by the surrounding vegetation community in the analysis region, but by available water, soil, stream channel substrate and morphology, elevation and latitude, climate, and land-use history (Brinson et al. 1981). Riparian communities are the most severely altered ecosystems in the United States (Brinson et al. 1981), resulting in diverse situations and intergrades between riparian and upland communities. Consequently, riparian communities are less likely to fit standard community descriptions than their adjacent uplands. Although riparian is not an analysis region, it is discussed separately here because it is not controlled by the same environmental factors as the analysis regions within which it occurs, nor is it directly related to the vegetation of the uplands of the analysis region.

Sagebrush

The sagebrush analysis region occupies extensive areas in the Upper and Lower Basin and Range Provinces, the Colorado Plateau, the Columbia Plateau, and the Wyoming Basin. It is also scattered throughout the northern, central, and southern Rocky Mountains (Figure 2-2 and Figure 2-3). It is one of the most extensive vegetation types on BLM lands in the EIS area.

Natural habitat differences within the region are great, ranging from near desert to subalpine climates and including a wide variety of physiographic and soil types (Tisdale and Hironaka 1981). Most of the sagebrush zone is found at elevations from 2,000 to 7,000 feet (Wright et al. 1979). Sagebrush communities may also occur up to 10,000 feet in the mountain ranges of the EIS area (Cronquist et al. 1972). Where sagebrush dominates below 7,000 feet, annual precipitation varies between 8 and 20 inches (Wright et al. 1979).

Environmental diversity has resulted in a comparable variety of species, subspecies, and varieties of sagebrush adapted to specific habitats (Tisdale and Hironaka 1981), although overall floristic diversity of the analysis region is moderate to low (West 1983). Basin big sagebrush and Wyoming big sagebrush usually dominate between 2,000 and 7,000 feet. Basin big sagebrush occupies deep, well-drained alluvial soils where annual precipitation averages 10 to 16 inches, and Wyoming big sagebrush occupies an 8- to 12-inch precipitation zone on shallow soils (Wright et al. 1979). Mountain big sagebrush can be found at elevations from 5,000 to 10,000 feet where annual precipitation varies from 14 to 20 inches (Wright et al. 1979).

The aspect of the typical sagebrush community is fairly dense to open vegetation with nonspiny shrubs 2 to 6 feet high and an understory of perennial and annual grasses and forbs (Cronquist et al. 1972). Increasingly to the south, however, sagebrush may grow to the virtual exclusion of grasses and does not represent a grazing disclimax (Brown et al. 1982). Important shrubs in the sagebrush analysis region include big sagebrush, black sagebrush, low sagebrush, rabbitbrushes, Mormon tea, bitterbrush, snowberry, and horsebrush (Cronquist et al. 1972). Important perennial grasses include bluebunch wheatgrass, Sandberg bluegrass, Idaho fescue, western wheatgrass, Great Basin wildrye, junegrass, Indian ricegrass, squirreltail, muttongrass, needle-and-thread grass, and Thurber needlegrass. Red brome and cheatgrass are introduced annual grasses that have become abundant. Common forbs include wild onion, sego lily, balsam root, Indian paintbrush, larkspur, rubberweed, lupine, phlox, locoweed, mulesear, and various annual mustards (Cronquist et al. 1972).

The most dependable combination of both moisture and temperature conditions favorable for growth occurs for a short period after snowmelt. Growing season precipitation is less dependable for soil moisture recharge, and higher temperatures cause greater evapotranspirative losses. The

1 Northern Pacific Border
2 Cascade Mountains
3 Columbia Plateau
4 Northern Rocky Mountains
5 Upper Basin and Range
6 Lower Basin and Range
7 Colorado Plateau
8 Middle Rocky Mountains
9 Upper Missouri Basin and Range
10 Black Hills Uplift
11 Wyoming Basin
12 Southern Rocky Mountains
13 Rocky Mountain Piedmont
14 Great Plains
15 Central Lowlands
16 Ozark Plateau

Source: A.W. Kuchler, Potential Natural Vegetation of the Conterminous United States, Second Edition (American Geographical Society, 1975) with BLM Physiographic Regions by Kenneth Brown and Richard Kerr, 1979.

Figure 2-3
Physiography of the States in the Study Area

grasses and forbs depend on resources in the surface soil in the interspaces between shrubs and therefore have a constrained growing period. Sagebrush can draw its moisture and nutrients from deep in the profile or through fibrous roots near the surface, giving it extreme resistance to environmental extremes (West 1983). Sagebrush is also long-lived (in excess of 40 years), has great reproductive capacity through abundant and consistent seed set, and produces secondary chemical compounds in its foliage that probably discourage herbivory (West 1983). Altogether, these characteristics make sagebrush extremely competitive in this environment (West 1983). Sagebrush is killed by fire, however, and insects and fire appear to be its primary environmental vulnerabilities (West 1983).

Disturbances from cultivation, fire, herbicides, excessive grazing, and insects, combined with natural variability, have changed the botanical composition and productivity of native sagebrush communities. Since the beginning of European settlement, the abundance of many native species has been reduced, sagebrush has become more abundant, and many exotic species, mostly annuals, have invaded the region (Tisdale and Hironaka 1981). Cheatgrass competition provides a major barrier to the seedling establishment of other species and has replaced the native bluebunch wheatgrass over wide areas (Cronquist et al. 1972). However, the sagebrush region itself is ecologically stable and its boundaries closely resemble those at the time of European settlement (Tisdale and Hironaka 1981).

Before 1900, domestic stock had greatly reduced the more palatable herbaceous component of the sagebrush region, as most varieties of sagebrush are not highly palatable to domestic stock, especially during the growing season (Tisdale and Hironaka 1981). Affected areas were susceptible to invasion by aggressive, less palatable species, particularly introduced annuals, such as cheatgrass and medusahead (Brown 1982, Tisdale and Hironaka 1981, West 1983). Improved management systems or complete elimination of livestock will not change this situation through natural ecological succession within any reasonable timeframe (Bowns 1990). Cheatgrass and medusa-head produce enormous numbers of seedlings after the first fall rain, and their root systems can grow throughout most of the winter. Native perennial grasses have higher soil temperature thresholds for growth. By the time spring comes, these annuals have built extensive root systems that can use soil moisture both earlier and at higher rates than the native grasses (West 1983). The annual grasses generally dry out by mid-June, and the dry stands are very susceptible to wildfire.

The fire history of the sagebrush region has not been firmly established, but fire was probably uncommon on drier sites because of sparse fuels, and more frequent, averaging 32 to 70 years, on more mesic sites with greater herbaceous production (Wright et al. 1979). Incidence of wildfire has contributed significantly to the dominance of cheatgrass on millions of acres in the Upper Basin and Range and the Columbia Plateau. Burning every few years or burning in early summer depletes perennial grasses and encourages annuals, which create very flammable fuel and further increases fire frequency (Wright and Bailey 1982; West 1983). Once established on a site, cheatgrass may virtually exclude perennial native species, thereby perpetuating the cheatgrass fire cycle, leading to a spiral of deterioration through depletion of volatile nutrients and accelerated soil erosion (West 1983). The increasing acreage of these fire-perpetuated cheatgrass communities and resulting loss of sagebrush habitat is a cause of great concern to land managers in the Upper Basin and Range and Columbia Plateau. Protection and restoration of native sagebrush communities must be a management consideration in some areas of this analysis region. Reclamation of these sites to perennial vegetation requires intensive techniques such as chemical fallow (Eckert and Evans 1967) or plowing and seeding (Wright and Bailey 1982).

Desert Shrub

The desert shrub analysis region is a composite of generally the most arid portions of the Upper and Lower Basin and Range Provinces, the Colorado Plateau, the Wyoming Basin, and the Columbia Plateau (Figure 2-2 and Figure 2-3). This analysis region includes the hot and cold deserts of the Western United States, which are dominated by shrubs in open stands, with a large amount of bare soil or desert pavement exposed. Understory vegetation is generally sparse, except when flushes of annuals are produced by seasonal precipitation in the hot deserts.

The vegetation of both the hot and cold desert has adapted to a low rainfall regime of 2 to 15 inches annually (Benson and Darrow 1981). Desert plants have evolved different ways to survive the harsh growing conditions prevalent in this region. Annuals germinate while temperature and moisture conditions permit them to grow to maturity and produce seed, often within a single season; the seed remains in the soil until favorable growing conditions occur once again. Certain perennials, called phreatophytes, develop extensive root systems that reach the water table. Perennial shrubs often have deep root systems that access deep soil moisture, as well as shallow roots that compete with herbaceous vegetation for surface moisture. Some plants, such as cacti and other succulents, have special tissue that allows them to store moisture in their stems or leaves. Other adaptations of desert plants include various combinations of small leaf size; thick waxes,

resins, or pubescence on leaf surfaces; and the ability to drop leaves and go into dormancy in response to drought. High soil salinity or alkalinity constitute yet another difficulty by presenting a physiologically dry environment. For example, areas in the Columbia Plateau and Wyoming basin support salt-desert shrub communities because of salty and fine textured soils in a climatic regime that would otherwise support grassland (Blaisdell and Holmgren 1984). Plants in these areas have developed physiological processes to remove excess salts from their tissues and regulate salt uptake by the roots.

The Mojave and Sonoran Deserts constitute the hot desert portion of the analysis region. Located mostly in California, the Mojave extends into southern Nevada, northwestern Arizona, and the tip of southwestern Utah. It is a transitional area between the cold desert and the Sonoran Desert and shares many species with both (Brown 1982). Precipitation occurs mostly in the winter. The Joshua tree is the most widely recognized, but not the most widespread, species of the Mojave. Common shrubs include creosotebush, bursage, thornbush, shadscale, all scale, spiny hopsage, and greasewood. Pickleweed, seep weed, alkali weeds, glassworts, and saltgrass are common species associated with saline basins. The Mojave Desert is especially rich in annual plants, which are abundant during the rainy season in winter and spring (Brown 1982).

The Sonoran Desert receives summer and winter precipitation, separated by spring and fall drought (Brown 1982). It is characterized by a high percentage of trees and large shrubs, and is particularly rich in succulents (Benson and Darrow 1981). Saguaro is characteristic of the mostly frost-free portions of the Sonoran Desert. Other common shrubs and succulents include creosotebush, blue palo verde, bursage, mesquite, desert ironwood, allthorn, ocotillo, jojoba, acacia, and many species of Opuntia, yucca, and agave. Annual herbs are abundant after summer and winter rains (Benson and Darrow 1981).

The cold desert portion of the analysis region occurs in the rainshadow east of the Sierra and Cascade ranges throughout Nevada, western Utah, southeastern Oregon and southwestern Idaho, and to the east in the Wyoming Basin and Colorado Plateau. These areas are dominated by low-growing, much branched, mostly nonsprouting, spineless shrubs; and species diversity is characteristically low (Brown 1982). Most precipitation comes in the winter in the western portion of the region, with a gradual shift toward a stronger summer influence to the east, where wet and dry seasons are less distinct than in other deserts (Brown 1982). Shadscale is characteristic of these areas. Other important shrubs include winterfat, Mormon tea, gardner saltbush, mat saltbush, black sagebrush, fourwing saltbush, rabbitbrush, greasewood, horsebrush, bud sagebrush, and snakeweed. Common annual species include exotics such as halogeton, Russian thistle, and cheatgrass. Scattered perennial grasses include galleta, Indian ricegrass, squirreltail, alkali sacaton, and Sandberg bluegrass (Blaisdell and Holmgren 1984). Blackbrush dominates some cold desert areas in southeastern Utah, where it forms communities with scattered individuals of Mormon tea, buckwheats, shadscale, sandsage, indigobush, snakeweed, galleta, and cheatgrass (Cronquist et al. 1972).

The effects of historic use on hot and cold desert communities vary. Changes in some communities are well documented, while in others little change has occurred. The causes of observed change are complex and not always entirely understood. Quantitative data on the extent of change in this region is rare (Branson 1985).

Low amounts of above-ground biomass and widely spaced individuals make wildfire a rare occurrence, and fire has not been documented as an ecologically important factor in the development or maintenance of these communities either before or after settlement. However, grazing by domestic stock has caused vegetation changes in these communities, particularly the cold desert. The nature of the changes is related to the kind of livestock, season and intensity of use, and site potential (Branson 1985). Since these areas have always been dominated by shrubs, the observed changes include reduction of total cover or reduction of palatable shrub or grass species, such as black sagebrush, bud sagebrush, winterfat, and Indian ricegrass, which are replaced by shrub species not grazed by livestock or by exotic annuals, such as halogeton and Russian thistle (Branson 1985). In addition to livestock grazing, disturbances such as construction of energy and transportation corridors, military operations, surface mining, and recreation have created depleted vegetation conditions in this part of the analysis region (Blaisdell and Holmgren 1984).

Hastings and Turner (1965) concluded that warmer temperatures and less rainfall in the past 100 years must be considered the principal cause of vegetation change in much of the Sonoran Desert (Branson 1985). However, depletion of saguaro populations in parts of the Sonoran Desert has been attributed to suppression of reproduction by livestock grazing (Branson 1985).

Southwestern Shrubsteppe

The southwestern shrubsteppe analysis region occupies most of the Lower Basin and Range Province in southeastern Arizona eastward through southern New Mexico (Figure 2-2 and Figure 2-3). It includes the semidesert grasslands of southeastern Arizona and southern New Mexico, and the Chihuahuan Desert.

Elevations of the semidesert grasslands range from 3,300 to 5,000 feet (Brown 1985). More than half of the 10 to 20 inches of annual precipitation falls during the summer growing season (Benson and Darrow 1981). These grasslands are best developed on deep, well-drained soils on level sites on the higher plains. Their aspect is a grassy landscape broken up by large, well-spaced shrubs. In the southwest they often form an alternating landscape mosaic with Chihuahuan desertscrub (Brown 1985). Large acreages of this grassland are now dominated by mesquite, tarbush, acacia, and creosotebush (Brown 1985). Black grama and tobosa are the most characteristic grasses of the semidesert grasslands. Other important grasses on the better sites include sideoats grama, hairy grama, other gramas, bush muhly, vine mesquite, Arizona cottontop, slim tridens, pappus grass, tanglehead, threeawns, and curly mesquite (Brown 1985). The introduced perennial Lehmann lovegrass now occupies extensive areas in some western portions and is spreading at the expense of more palatable native grasses (Brown 1985). Other shrubs and succulents characteristic of this grassland include yuccas, bear grass, sotol, agaves, allthorn, sumac, hackberry, Javelina-bush, ocotillo, acacias, and mimosas. Many species of cacti occur throughout the drier sites, especially on rocky outcrops.

The northernmost extensions of the Chihuahuan Desert are also included in this analysis region, where it occupies rain shadow basins, outwash plains, low hills, and bajadas across southern New Mexico. Elevations range from about 1,200 to 5,000 feet. Precipitation is highly variable from year to year, but averages approximately 8 to 12 inches, and falls mostly in the summer when evapotranspiration rates are high (Brown 1982). Perennial vegetation of this desert consists largely of shrubs. Creosotebush, acacias, and tarbush dominate the intermountain plains and lower bajadas. Mesquite dominates sandy, wind-eroded hummocks. Dense stands of succulents, such as lechuguilla, sotol, yuccas, beargrass, and candelilla, occur on rocky mountain slopes in association with scattered ocotillo and many species of cacti, including Opuntia, Ferocactus, Echinocereus, Echinocactus, and Mammillaria. Annuals are important components only during the summer rainy period. Principal understory species include mariola, goldeneye, desert zinnias, and dogweeds.

The expansion of Chihuahuan Desert into former grassland is well documented and continues to be observed today (Brown 1982), but the mechanisms by which the encroachment has occurred are not well understood (Wright 1980). The desert grasslands are thought to have been burned frequently by Indians (Benson and Darrow 1981). This practice kept encroachment of woody species to a minimum. Frequent burning ceased with the coming of European settlement. The combination of reduced fire frequency and overgrazing by settlers' livestock resulted in an expansion of woody communities from lower and higher elevations. Cattle helped spread mesquite by depositing undigested mesquite seeds throughout the grassland (Benson and Darrow 1981).

Loss of ground cover resulted in loss of topsoil in some areas, to the point that the site could no longer support a grassland community (Branson 1985). Thus, the change to shrubland in some parts of the region may be permanent. Fire exclusion continues to be considered an important factor in the continued occupation of former grassland areas by woody species. Increase of woody species has continued in areas protected from grazing (Humphrey and Mehrhoff 1958). Others, however, discount the importance of fire, particularly in the maintenance of brush-free range in southern New Mexico (Buffington and Herbel 1965), where there is less supportive evidence of fire occurrence.

Hastings and Turner (1965) made a case for climatic trends toward warmer and drier conditions, combined with historic overgrazing, as a cause of vegetation changes in this region, but this theory is not universally accepted (Wright 1980). Other studies have documented that certain woody species, such as burroweed, are highly responsive to short-term climatic trends, and that such natural causes by themselves can be responsible for dramatic shifts from grasses to shrubs (Martin and Turner 1977). Wright (1980) concluded that occasional fires, in combination with drought, competition, rodents, and lagomorphs played a significant role in controlling shrubs in this region, with the exception of black grama uplands.

Chaparral-Mountain Shrub

The chaparral-mountain shrub analysis region occurs in mountain areas throughout the Upper and Lower Basin and Range Provinces and is scattered through the northern, central, and southern Rocky Mountains (Figure 2-2 and Figure 2-3). It is a composite of interior chaparral and mountain shrub communities.

The interior chaparral discontinuously occupies mid-elevational foothill, mountain slope, and canyon habitats in Arizona below the Mogollon Rim, and occurs as isolated communities through the drier mountains of southern New Mexico (Brown 1982). Precipitation averages 15 to 25 inches annually in a summer-winter pattern separated by spring and fall drought (Brown 1982, Davis and Pase 1977). Vegetation communities consist of dense to moderately open stands of evergreen, and sclerophyllus shrubs of relatively uniform height. Most chaparral shrubs are deep-rooted, sprout readily from the root crown,

and regenerate quickly after burning (Brown 1982). Shrub live oak is a common dominant of the interior chaparral. Associated shrubs include mountain mahogany, yellowleaf silktassel, sumac, hollyleaf buckthorn, pointleaf and Pringle manzanita, desert ceonothus, other oak species, and sophoras. Important grasses are now largely confined to rocky, protected sites in the gentler terrain, and include sideoats and hairy grama, cane bluestem, plains lovegrass, threeawns, and wolftail. Forbs are not particularly abundant except for a brief period after burns (Brown 1982).

The mountain shrub type is found in higher foothill and mountain regions of Colorado, Utah, Nevada, New Mexico, and southern Idaho from approximately 5,000 feet to higher than 8,000 feet, depending on latitude. Aspect is that of a thicket up to 18 feet in height, or a relatively open stand. This type is typically positioned on the altitudinal gradient above pinyon-juniper woodland and below coniferous forest (Brown 1982). Precipitation varies from 15 to 21 inches annually and is spread throughout most of the year (Brown 1982). The combination of low precipitation and poor soil development on steep slopes precludes the establishment of more mesic communities (Brown 1982). The dominant species of the mountain shrub areas is Gambel oak. Other important shrub species include mountain mahoganies, snowberries, serviceberries, chokecherry, buckbrushes, New Mexican locust, and cliffrose. In the northern areas, bigtooth maple, bitterbrush, sagebrushes, rabbitbrushes, wild rose, elderberry, and currants are locally common. Scattered individuals of ponderosa pine and Douglas-fir occur throughout. Grasses are often scarce, and consist primarily of bluegrass, brome, needlegrass, and wheatgrass. Common forbs include yarrow, lupines, fleabane, groundsels, penstemons, dandelion, and mulesear.

Shrub densities in some areas of interior chaparral have increased since the turn of the century (Brown 1982, Herbel 1985). Reduction of fire frequency is usually considered to be the primary factor causing this trend (Brown 1982, Herbel 1985). Significant changes in vegetation are not well documented for the mountain shrub type. There has been a general depletion of palatable herbaceous components from past livestock grazing (Brown 1982) and a reduction in fire frequency as well. Exclusion of fire has contributed to decadent stands of shrubs that have lost much of their value for wildlife browse.

Pinyon-Juniper

The pinyon-juniper analysis region occurs at mid elevations in the Upper and Lower Basin and Range Provinces, the Colorado Plateau, the central and southern Rocky Mountains, and the Columbia Plateau (Figure 2-2 and Figure 2-3). It is a cold adapted evergreen woodland characterized by the unequal dominance of two conifers, juniper and pinyon pine. It is one of the most extensive vegetative types on BLM lands in the EIS area.

The pinyon-juniper woodland reaches its greatest development on mesas, plateaus, piedmonts, slopes, and ridges from 3,200 to 8,400 feet (Blackburn and Tueller 1970, Evans 1988). Precipitation ranges from 10 to 25 inches annually (Blackburn and Tueller 1970).

The eastern woodlands receive more summer precipitation than western areas, where most of the precipitation comes during the winter as snow (Brown 1982). The aspect of these woodland communities is highly variable. Trees rarely exceed 36 feet in height, and may present a closed canopy of single or many tree species with little or no understory vegetation, or the community may appear as an open stand of scattered trees with a diverse and well-developed understory (Evans 1988). Pinyon-juniper communities occur on a wide variety of soils, ranging from shallow to moderately deep and from coarse and rocky to fine compacted clays (Evans 1988). Current climate is more important than are soils in delimiting the elevational distribution of pinyon-juniper woodlands (Evans 1988). The principal contact is with sagebrush-grassland at the lower elevational limits where moisture is a limiting factor, and with chaparral-mountain shrub or montane conifer forest at the upper elevational limits where temperature is a limiting factor (Brown 1982, Wright et al. 1979).

Typically, juniper is found in pure stands at the lower elevational limits of the zone and may extend into the sagebrush zone. At higher elevations, pinyon enters the community, forming a mixed woodland throughout the middle of the elevational range, and eventually replaces juniper at the upper limits of the zone (Cronquist et al. 1972). The woodland exhibits wide geographic variation, with different tree species, different shrub species, and different herbaceous understory. Pinyon is absent from most woodland stands in eastern Oregon, Idaho, and western Wyoming. Throughout most of Nevada and western Utah, singleleaf pinyon dominates, along with Utah and western junipers. Singleleaf pinyon is replaced by doubleleaf pinyon throughout the Colorado Plateau and east into the central and southern Rocky Mountains. Rocky Mountain juniper, Utah juniper, and oneseed juniper are common associates (Cronquist et al. 1972). In the dry mountains of southern New Mexico and sub-Mogollon Arizona, Rocky Mountain and Utah juniper and doubleleaf pinyon disappear, and alligator juniper (a sprouting species of juniper), Emory oak, gray oak, and Mexican pinyon appear (Brown 1982). The associated understory layer of shrubs, grasses, and

forbs in these communities is commonly composed of representatives from adjacent sites above and below the woodland zone, and varies widely.

The correlation of pinyon-juniper presence to soil properties, climate, or topography is highly variable, and these species can become dominant wherever their moisture and temperature requirements are met (Brackley 1987). The range of the pinyon-juniper community types overlaps that of many other vegetation types, including sagebrush, semi-desert and plains grassland, mountain shrub, and ponderosa pine (West and Van Pelt 1987).

Fires are believed to have been widespread in most of the pinyon juniper type before settlement, and limited the extent of the community (Burkhardt and Tisdale 1976; Brackley 1987; Branson 1985; Leonard et al 1987; West and VanPelt 1987; Tausch et al 1981; Wright 1990), particularly in areas where it overlapped the range of communities with more fire tolerant species. Wright (1990) states: "Historically, fire has been the dominant force controlling the distribution of pinyon-juniper, particularly juniper, but fire cannot be separated from the effects of drought and grazing."

Droughts and competition from grass probably slowed down the invasion of juniper into adjacent shrublands, particularly at lower elevations. Because young pinyon and juniper trees are easily killed by fire, occasional fires would kill most trees establishing in an area. West and Van Pelt (1987) believe that many pinyon-juniper sites used to cycle between grass/shrub domination, and pinyon-juniper communities, with fire as the chief driving factor. There are stands of pinyon and juniper, however, such as in the upper Rio Grande River drainage where fire probably had little importance (Branson 1985). These may be areas of rough topography or poor soils that did not produce enough fuel to carry a fire (Wright et al 1979).

At the time of settlement, grazing by domestic livestock significantly reduced the amount of fuel. Without fuel, fires could not carry. Fire frequency decreased considerably, and the range and density of pinyon and juniper increased (Burkhardt and Tisdale 1976; Branson 1985; Tausch et al 1981; Wright 1990). Viewpoints in opposition to this explain that pinyon and juniper are merely reestablishing themselves on areas where they were removed for mining and other uses in the 1800's (Lanner 1977). Extensive removal of pinyon and juniper did occur in the central Great Basin, particularly central Nevada, where demand for charcoal, fuelwood, and fenceposts continued into the 1920's (Young and Budy 1987). However, it is unclear how much demand and removal of these species occurred in other areas where pinyon and juniper appear to be expanding their range.

Mehringer and Wigand (1987) argue that in central Oregon, the present rate and degree of expansion in juniper communities is no different than that which has occurred at other time periods in the last 10,000 years, and that climate, not grazing or fire exclusion is the cause of the expansion. Davis (1987) thinks that the migration of pinyon and juniper to lower elevations is in response to climatic cooling but that it has been accelerated by historic vegetation disturbance, particularly grazing.

Tausch et al (1981) studied pinyon and juniper age and dominance on 18 mountain ranges throughout the Great Basin, and found many stands of trees that predate the historic period. However, tree dominance is increasing, particularly at lower elevations, with about 30 percent of their plots containing trees that established between 1845 to 1895. They acknowledge the role of grazing and reduced fire frequency, as well as revegetation of formerly denuded areas as important factors to consider when explaining present pinyon and juniper expansion. No juniper trees were found that predated 1880 in a study area in north-central Oregon.

Many of the oldest trees established under sagebrush plants that have since died, while younger trees establish under the canopy of other junipers (Eddleman 1987). Significant loss of understory vegetation (Tausch et al 1981; Brackley 1987; Eddleman 1987; West and Van Pelt 1987) that provides food for both livestock and wildlife has and continues to occur in many of these stands. Most authors conclude that trees will continue to dominate more area without some major environmental change or management action. Improved management or complete elimination of livestock grazing will not change this situation (Bowns 1990).

Mountain/Plateau Grasslands

The mountain/plateau grasslands analysis region consists of noncontiguous areas of moderate to high elevation grassland scattered through the northern, central, and southern Rocky Mountains, and the Palouse grasslands of the Columbia Plateau (Figure 2-2 and Figure 2-3). It is one of the least extensive analysis regions BLM administers in the EIS area.

The mountain grasslands occur as part of the vegetation mosaic created by the highly complex environment of the Rocky Mountains. They occur at elevations ranging from 3,000 to over 9,000 feet where annual precipitation varies from 8 to 30 inches (Garrison 1977, Mueggler and Stewart 1980), at least half of which usually falls during the growing season. These grasslands occupy a variety of topographical positions, from level areas or valley floors, to alluvial benches and foothills, to steep mountain slopes. Soil characteristics vary accordingly, ranging from deep

and loamy, to poorly drained or fairly dry and rocky, or mildly alkaline to mildly acidic (Mueggler and Stewart 1980). The grass component of these communities is usually the most productive, followed by forbs, and then shrubs. Important grasses in these communities include bromes, bluegrasses, oatgrasses, sedges, wheatgrasses, fescues, needlegrasses, hairgrasses, reedgrasses, bentgrasses, and junegrass. The forb component varies with site, latitude, and management, and is diverse throughout the region. Shrubs that occur in these communities include big sagebrush, fringed sagebrush, silver sagebrush, rabbitbrushes, snakeweed, shrubby cinquefoils, wild roses, horsebrush, and prickly pear (Mueggler and Stewart 1980).

The Palouse grasslands characterize the part of the analysis region in eastern Oregon, Washington, and western Idaho. Precipitation of these grasslands is about 18 to 24 inches annually, and elevations range from 2,000 to 3,000 feet. Important dominants include bluebunch wheatgrass, Idaho fescue, Sandberg wheatgrass, and rough fescue. Many introduced species have adapted well to the region, and perennial native vegetation replaces them slowly or not at all after disturbance (Branson 1985). These exotic species include Kentucky bluegrass, a perennial, and annuals such as cheatgrass, medusahead, soft chess, rattlesnake brome, filaree, and Klamath weed.

Between the mountain and Palouse grasslands, the most extensive vegetation changes since European settlement have occurred in the Palouse grasslands, where extensive cultivation, overgrazing, and introduced plants have dramatically reduced the extent of native vegetation (Branson 1985). Many of the introduced species are Mediterranean annuals that are well adapted to grazing and the predominantly winter precipitation regime, which is why the native species cannot readily displace them.

Plains Grasslands

The plains grasslands analysis region is the western part of the Great Plains and stretches from eastern Montana through eastern Wyoming, Colorado, and New Mexico (Figure 2-2 and Figure 2-3). This grassland forms a broad, flat belt of land that slopes gradually eastward from the eastern foothills of the Rocky Mountains, composed of tall, mixed, or shortgrass communities, with the latter the most extensive in the EIS area.

The short grassland communities stretch from southeastern New Mexico through eastern Colorado to southeastern Wyoming. Annual precipitation varies from 11 to 20 inches, and elevations are from about 6,000 feet on the western edge to 3,000 feet on the eastern edge (Wright et al. 1980). Dominant grasses are buffalograss and blue grama, with smaller amounts of threeawns, lovegrass, tridens, sand dropseed, side-oats grama, tobosa, galleta, vine mesquite, and bush muhly. Forbs are seldom a major component, except during wet years (Wright et al. 1980). Dominant woody plants include honey mesquite, shinnery oak, sand sagebrush, snakeweed, yucca, and fourwing saltbush, cholla, and prickly pear (Wright et al. 1980).

The mixed grass communities stretch from northeastern Wyoming through North and South Dakota and eastern Montana. Precipitation varies from 20 to 28 inches, increasing from west to east. Elevation ranges from about 3,000 feet at the western edge to 900 feet in Texas (Wright et al. 1980). Sedges and cool season grasses, such as needlegrasses, wheatgrasses, and fescues, dominate the communities of Montana and North and South Dakota. Warm-season grasses, particularly blue grama, are also part of these communities, and increase in dominance going south. Other important grasses in mixed grass communities include green needlegrass, prairie sandreed, needle-and-thread grass, junegrass, sand dropseed, buffalograss, side-oats grama, threeawns, silver beardgrass, sand bluestem, plains lovegrass, and vine mesquite (Brown 1982, Wright et al. 1980). Shrub species found in these communities include juniper, silver sagebrush, silver buffaloberry, sumac, wild rose, and rabbitbrushes, yucca, snakeweed, cholla, and winterfat. (Brown 1982, Mueggler and Stewart 1980). Forbs may be an important component of these communities. Common species include goldeneye, groundsel, sunflowers, primrose, globemallow, asters, scurf pea, coneflower, and bricklebush (Brown 1982).

Tall grass communities in the plains grassland are restricted to certain soil types and areas where grazing history has not been severe (Brown 1985). This type is much more extensive in the true prairie of the midwest. Tall grass communities are dominated by big bluestem, little bluestem, Indian grass, switchgrass, and side-oats grama. Associated shrubs include shinnery oak, sandsage, yucca, and mesquite (Brown 1985).

The plains grasslands evolved with grazing by native herbivores, and many of the grasses are well adapted to grazing. Climate is generally believed to be the dominant factor controlling these grasslands, but periodic fire was also an important factor in limiting woody vegetation to mosaics or a savanna situation (Wright et al. 1980). Fire suppression has led to the establishment of fire disclimax associations of shrubs in some areas (Brown 1982). In general, the plains grassland has not been subject to the extensive type conversions from fire suppression and other human activities that have occurred in some of the other native grasslands.

Coniferous/Deciduous Forest

The coniferous/deciduous forest analysis region is a composite of the many high-elevation evergreen conifer and deciduous forest types that occur throughout the northern, central, and southern Rocky Mountains, as well as the mountains of the Upper and Lower Basin and Range Provinces, the Colorado Plateau, and the Columbia Plateau (Figure 2-2 and Figure 2-3). Species dominance varies with altitude, latitude, slope aspect or other topographical position, soil characteristics, and climatic regime. BLM administers small acreages of these diverse forest types in every State in the EIS area. Important forest communities included in this analysis region are climax ponderosa pine, seral ponderosa pine, Douglas-fir, Douglas-fir mixed with other conifers, aspen, lodgepole pine, cedar-hemlock, and spruce-fir.

Climax ponderosa pine exists at the lower elevations and on the warmer, drier sites of the analysis region. The lower contact is typically with pinyon-juniper woodland or chaparral-mountain shrub communities. Upper elevation contacts are usually with mixed conifer types. Ponderosa pine is the largest western forest type (Brown 1985) and occurs in every State in the EIS area. Old growth ponderosa forests are often park-like, with scattered old trees interspersed with groups of young trees. There is typically a well-developed herbaceous understory. Stands were probably kept open by light fires that periodically burned through the understory. Older trees tolerate fire well, but young trees are easily killed (Daubenmire 1952). In the absence of frequent understory fires that historically occurred, many stands of ponderosa pine are now dense and stagnant, with thickets of understory reproduction (Wright and Bailey 1982).

On more mesic sites, ponderosa pine will be replaced by other, less fire-tolerant species without understory fires. In northeast Oregon and central Idaho, ponderosa pine is seral to grand fir and Douglas-fir. Ponderosa pine is associated with western larch and Douglas-fir in central and northeast Washington, northern Idaho, and western Montana, where it grades into more moist western larch and Douglas-fir forests at higher elevations or more northerly aspects. Because ponderosa pine and western larch are the most fire resistant western trees, infrequent underburns would favor these species over Douglas-fir or grand fir (Wright and Bailey 1982).

The Douglas-fir zone occurs in the northern and central Rocky Mountain regions, from eastern Washington, Idaho, western Montana, and northwestern Wyoming, generally between the ponderosa pine and spruce-fir zones (Wright and Bailey 1982). Ponderosa pine, western larch, aspen, and lodgepole pine are common seral species in this zone (Wright and Bailey 1982). Associated understories may be dominated by bunchgrasses on the most xeric sites, or may be composed of a sparse shrub layer mixed with grasses and forbs (Wright and Bailey 1982).

Douglas-fir is more often mixed with other conifer species types in the southern Rockies. This mixed conifer zone is dominated by Douglas-fir in association with white fir, blue spruce, or Englemann spruce. Mature mixed-conifer forests are often dense, with high litter accumulations that inhibit understory growth (Brown 1985). This type may extend into much drier areas, following canyons, ravines, and north-facing slopes, existing as islands in the midst of more xerophytic vegetation (Daubenmire 1952).

Quaking aspen is the most widely distributed native North American tree species (DeByle et al. 1985). Its range coincides closely with Douglas-fir. Aspen may form extensive pure stands or be a minor component of other forest types. Aspen is a clonal species; that is, its extensive root system gives rise to shoots that form new trees that are genetically identical to the parent. The clone consists of all the genetically identical stems. Aspen clones may persist for thousands of years (DeByle et al. 1985). A stand may be composed of one or many clones. Fire is responsible for the abundance and even-aged structure of most stands throughout the West. Without human intervention, fire appears to be necessary for the continued well-being of aspen on most sites (DeByle et al. 1985), and most stands will die out or be replaced by conifers without disturbance.

Lodgepole pine occurs primarily in the central and northern Rocky Mountain regions of Colorado, Wyoming, Montana, Utah, Idaho, and Oregon. At higher elevations, it gives way to spruce-fir forest. Lodgepole pine forms dense, often pure stands with little understory. Fire plays an important role in the maintenance of these forests. The Rocky Mountain lodgepole pine contains some proportion of closed cones that retain seeds but quickly release them after fire or cutting (Lotan et al. 1981). Lodgepole pine colonizes burned areas, frequently replacing previous stands of lodgepole pine. Without fire, lodgepole pine may eventually be replaced by ponderosa pine, Douglas-fir, Englemann spruce, cedar-hemlock, or Englemann spruce/subalpine fir stands. Lodgepole pine may persist as a climax species on sites too cold for Douglas-fir or ponderosa pine, too dry for spruce-fir, or too wet or infertile for other coniferous species (Wright and Bailey 1982).

In the EIS area, cedar-hemlock occurs in northern Idaho and northwestern Montana where the westerlies carry oceanic influence as far inland as the continental divide. The zone is characterized by higher precipitation than the other conifer zones, and

summer heat is adequate (Wright and Bailey 1982). Dominant trees are western hemlock and western redcedar. Grand fir is climax dominant in the southern portions of the region. Douglas-fir and western white pine are common associates. Understory in this zone is a rich growth of shrubs and herbs (Wright and Bailey 1982).

The spruce-fir forest type is dominated by Englemann spruce and subalpine fir. Limber pine and bristlecone pine are common associates on steep, rocky, and southern exposures. Douglas-fir, aspen, lodgepole pine, blue spruce, and white bark pine are also found in this zone. These species often form dense stands with little herbaceous understory because of shading and considerable litter accumulation. Aspen generally becomes dominant after fire or other disturbance (Brown 1985).

Fire exclusion in any of these forest types adapted to high frequencies of understory fires can lead to accumulations of understory dead woody fuels, as well as the establishment of trees that provide fuel ladders between the surface fuels and the tree crowns, and it has substantially altered forest succession in some forest types (Barrett 1988, Stark 1977). Fire exclusion on forests with long stand replacement cycles results in increased fire hazard because flammability increases over much greater contiguous areas of forest and younger, less flammable stands are no longer present. For example, lodgepole pine stands that have had time to develop an understory of Englemann spruce and subalpine fir are much more flammable than before those species became established. Complete fire protection will allow less fire-tolerant species to replace more fire-tolerant species, as well as permit coniferous species to take over most sites presently dominated by aspen (DeByle et al. 1985).

Riparian Vegetation Communities

Riparian communities occur in all analysis regions, although they make up the least extensive vegetation type in the 13 Western States, with less than 1 percent of the total area (Cooperrider et al. 1986). Because of their productivity and other values, they are critically significant and have received continuous intensive use since presettlement times (Branson 1985). It is estimated that 70 to 90 percent of the natural riparian ecosystems have been lost because of human activities, and as much as 80 percent of the remaining areas are in unsatisfactory condition and are dominated by human activities (Cooperrider et al. 1986).

Riparian community descriptions do not easily fit into the analysis region format because they are controlled by different environmental factors than those that control the upland areas. The presence of water, the increase in humidity, and the modification of temperature within riparian areas allow upland vegetation to exist at significantly lower elevations; riparian-related blue spruce is an excellent example. Riparian zones are also much more complex than their adjacent uplands (Thomas et al. 1979), making them much more difficult to categorize.

There are several classification systems attempting to categorize all riparian vegetation communities; most of them are too complex for this type of general analysis. The classification system proposed by Dick-Peddie and Hubbard (1977) is appropriate for this EIS.

The Alpine Riparian Sub-formation is limited to riparian areas or above timberline. Typical plant species are shrubby willows, sedges, rushes, spikerush, marsh marigold, and Koenigia. This community occurs rarely on public lands and is not likely to be affected by any actions proposed in this EIS. The alpine riparian communities are limited to a few isolated mountain ranges within the sagebrush, pinyon-juniper, mountain/plateau grasslands, and coniferous/deciduous forest analysis regions.

The Montane Riparian Sub-formation contains three sub-series communities: the willow-alder series, blue spruce series, and the mixed-deciduous series. The willow-alder series includes several species of willow and alders, bog birch, water birch, dogwood, aspen, currant, geranium, cinquefoil, cow parsnip, and sedges. The vegetative community will be most closely associated with the mountain/plateau grasslands and coniferous/deciduous forest analysis regions. The blue spruce series contains the blue spruce and combinations of Douglas-fir, subalpine fir, white serviceberry, carex, grasses, and geranium. This series is also associated with the mountain/plateau grasslands and coniferous/deciduous forest as well as higher elevation sagebrush, chaparral-mountain shrub, and pinyon-juniper regions. The mixed-deciduous series includes a variety of communities of willow-dogwood, alder-willow, boxelder-ash-walnut, sycamore, and hackberry associations. Also found with these associations are junipers, ash, western oaks, cottonwoods, maple, and others. This series can be found in all analysis regions and includes a wide variety of understory vegetation.

The Arroyo-Floodplain Riparian Sub-formation contains the arroyo scrub series and the floodplain (bosque) series. The arroyo series occurs only in the driest riparian situations, generally with only seasonal flooding. It may not be considered true riparian by some classification systems, or may be considered xeroriparian (Warren and Anderson 1985). Most of the species are also found in the uplands, but reach a much larger size in the drainages because of the presence of flood or subsurface water. The associations occurring in this series are the greasewood, rabbitbush, desert willow-bricklebush,

and the burroweed-four-winged saltbush associations. In addition to the named species, others found are big sagebrush, seepwillow, desert broom, arrowweed, and the nonnative saltcedar. This series occurs primarily in the sagebrush, desert shrub, and southwest shrubsteppe analysis regions. The floodplain (bosque) series includes the cottonwood, cottonwood-willow, mesquite, arrowweed-seepwillow, mixed bosque, and saltcedar associations. This series is also widely occurring, allowing for a large variety of subdominate understory vegetation. The cottonwood-willow association may be found in virtually all of the analysis regions. Saltcedar, a rapidly spreading exotic, is also wide ranging and may be commonly found in all but the coniferous/deciduous analysis regions. The mesquite, arrowweed-seepwillow, and mixed bosque associations occur primarily in the desert shrub and southwestern shrubsteppe regions.

In the eastern portions of the plains grassland region, the riparian vegetation takes on some of the characteristics of the upland deciduous forests. In Oklahoma the riparian tree species decrease in height and vigor in the transition from the moist east to the arid west. Typical species also change. In the east, baldcypress, sweetgum, sycamore, river birch, and black gum are common. In the central region, elms, hackberry, walnut, black locust, and honey locust are dominant, but are secondary species in the east. In the west, cottonwood, willow, elm, and boxelder are common, but are smaller and more widely spaced than in the east (Brinson et al. 1981).

The history of riparian areas is one of wide-scale development and abuse. While a small number of western riparian areas have improved since the settlement of the West, such as the South Platte River (Branson 1985), most have undergone a significant reduction in quantity and quality. The lower Colorado River is a prime example. In historic times there were an estimated 5,000 acres of pure cottonwood stands along the Colorado. By the mid-1970s this had been reduced to about 500 acres. There are still 2,800 acres of cottonwood-willow stands, but these are heavily invaded with exotic saltcedar. The average removal rate of all riparian vegetation has been estimated at nearly 3,000 acres a year (Ohmart and Anderson 1982). The low elevation riparian communities have had the heaviest impacts, while mountain communities have not changed as dramatically (Brinson et al. 1981). Major impacts have been through land clearing for agriculture and settlements, irrigation projects and related water management, and flooding under impoundments. The overall assessment of riparian vegetation in the Western States is similar to the dramatic reduction that has occurred nationwide. Of an estimated 120 million acres of potential riparian habitat, less than 20 percent remains (Brinson et al. 1981).

Within the scope of this EIS, two aspects of historical change in riparian vegetation are important. Past-land use practices in livestock grazing, fire management, and timber harvest have had a significant effect on the current status of riparian areas. Most of the riparian areas still in existence are in poor condition because of past management (Cooperrider et al. 1986). Excessive quantities of plant biomass have been removed from riparian areas by livestock grazing and timber harvest for the past 100 years or more. The remaining riparian communities are often relict tree stands, unable to reproduce under existing management. In addition to damaging the riparian communities, past management has also degraded much of the associated upland vegetation areas, resulting in unsatisfactory condition watersheds in addition to the poor condition riparian areas (Brinson et al. 1981). The end result of the past abuses are riparian areas that are only remnants of the potential plant community, with surrounding watersheds that are unstable and need changes in management before riparian objectives can be met.

The second problem is still occurring and causes the need for most of the proposed vegetation treatments within riparian areas included in this document. This is the spread and apparent naturalization of saltcedar. Saltcedar is an exotic tree/shrub, introduced from Eurasia as an ornamental. It has adapted extremely well to the Southwest and is spreading north into most of the States included in this EIS. From its introduction in 1820 it had spread to 10,000 acres in 1920, 900,000 acres in 1961, to probably 1.3 million or more acres in the 1970s (Branson 1985). Because of its prolific seed production and its ability to resprout after attempted control, saltcedar has been nearly impossible to control and impossible to eradicate. However, continuing control efforts are appropriate because of competition with better quality riparian plant species.

Climate

Because climate is the driving force for vegetation growth and a key factor in erosion, specific climate conditions dictate vegetation management methods. The study region is made up of four main climatic types. The coastal Pacific Northwest is a temperate oceanic climate type. The deserts of central and southern Nevada; southwest Utah; northwest, western, and southern Arizona; and southern New Mexico are a subtropical, hot desert climate type. The mountainous regions of the Cascade and Rocky Mountains are a highland climatic type. The rest of the study region (where most nondesert BLM-administered lands are located) is a continental, cold steppe climate type.

Temperatures vary mostly with latitude, elevation, moisture, and to a lesser extent, local microclimate. At higher elevations, freezing temperatures are possible throughout the year.

Annual precipitation is highly variable, primarily because of the orographic effect of local topography. Snowfall is possible at higher latitudes and elevations throughout the year, with snow accumulation increasing with elevation.

Upper-level winds prevail from the west and southwest, but ground-level winds often reflect local terrain. For example, the diverse and rugged terrain in mountainous areas results in complex wind flows and surface winds. Synoptic (pressure gradient) winds may be channeled or forced around hills, but without strong gradient flows, diurnal upslope/downslope winds predominate. Upslope winds usually occur on sunny mornings when the air at higher elevations heats rapidly and rises. Downslope winds occur when the air near the ground cools, becomes dense, and sinks downward along drainages.

The extent to which vertical and horizontal mixing takes place is related to the atmospheric stability and mixing depth. Unstable conditions normally result from strong surface heating (typical of summer afternoons), producing vertical winds. Neutral conditions reflect a breezy, well-mixed atmosphere. Stable conditions (enhanced by rapid radiative cooling and downslope drainage, etc.) produce the least amount of dispersion.

Although atmospheric mixing varies throughout the study area, dispersion is normally good in spring and summer, but is limited in winter. Inversions are formed under stable conditions, trapping pollutants within a layer of air. Moderate summer inversions are typical during the evening and dissipate at dawn. Winter inversions are stronger and last longer. Inversions are enhanced by weak pressure gradients, cold clear nights, snowcover, and lower elevations.

The temperate oceanic climate type is dominated by moist, onshore winds. As a humid climate, precipitation is reliable and abundant; snow is found only at higher elevations. Evaporation is minimal. Seasonal temperature extremes are moderated by the warm North Pacific ocean current. Summer temperatures are cooler than other locations at similar latitudes; winter temperatures are milder. Given the high latitude, growing seasons are relatively short. The air is normally well-mixed, but valley inversions may form.

The subtropical, hot desert climate type is continental and very dry. Precipitation is minimal and highly variable. As a result, the desert is characterized by sunny days, clear nights, high evaporation, and large diurnal and seasonal temperature changes. Summer temperatures are among the highest in the world, and winter temperatures are mostly mild to cool. Wind may be caused by pressure gradients or local heating differences. Air is unstable during the day, but night-time inversions are common.

The highland climatic type is dominated by its mountainous topography. This complex topography causes considerable variation in site-specific temperature, precipitation, and surface winds. Precipitation is greatest on the windward side, with amounts increasing dramatically with elevation. Temperatures are much colder than lowlands at similar latitudes, and may become frigid when cold air drains into mountain valleys. Diurnal up- and down-valley winds predominate. Mountain inversions may form and last for several days.

The continental, cold steppe climate type is typified by low to moderate precipitation, which occurs mostly in summer. The amount of precipitation varies greatly from year to year. Evaporation is moderate to high.

Temperatures vary widely from cold winters and hot summers. There are four distinct seasons (spring occurs suddenly and warms quickly), but the timing and duration of the seasons vary by latitude. Pressure gradient (synoptic) winds predominate. Extremely frigid conditions and blizzards can occur, but severe weather conditions, such as floods and damaging hail, are rare. Tornadoes occasionally occur in the easternmost portion of the study area. Winter inversions are common and may last for several days.

The following climate analysis region descriptions are necessarily broad generalizations of very complex climatic conditions (USDA 1972.) Table 2-2 provides monitored data for specific locations within each analysis region. However, this data cannot be extrapolated throughout the analysis region. Figure 2-4 shows annual average precipitation throughout the study area. Site-specific monitoring is necessary to determine local climatic conditions.

Sagebrush

Average annual precipitation ranges from 8 to 20 inches, resulting mostly from summer convective thunderstorms. In northern and central Nevada, southeastern Oregon, eastern Washington, and southwest Idaho, very little precipitation falls in the summer months. Most precipitation occurs in the winter, falling as snow at all but the lowest elevations. January temperatures range from an average minimum temperature of 10° Fahrenheit (F) to an average maximum temperature of 40° F. July temperatures typically average from 50° F (minimum) to 90° F (maximum). Frost-free periods normally last 6 months.

Table 2-2

Climatic Data

Station	Vegetation Type	Elevation (ft; mean sea level)	Annual Mean Temp (°F)	Annual Mean Prec (")	Frost-Free Days
Ely, NV	Sagebrush	6,253	44.3	8.3	146
Las Vegas, NV	Desert Shrubland	2,162	65.7	3.9	319
El Paso, TX	SW Shrubsteppe	3,920	63.3	7.9	310
Payson, AZ	Chaparral/Mtn Shrub	4,902	55.5	21.0	222
Moab, UT	Pinyon Juniper	3,965	55.9	8.2	240
Billings, MT	No/central Plains	3,567	47.5	13.2	212
Amarillo, TX	Southern Plains	3,590	58.7	19.7	253
Rock Springs, WY	Mtn/plat Grass/Mead	6,741	42.7	7.8	170
Flagstaff, AZ	Southern Forests	6,993	45.6	18.3	155
Missoula, MT	No/central Forests	3,200	43.2	12.8	184
Olympia, WA	Pacific NW Forests	190	50.8	52.4	283

Note. Even though they are outside the EIS study area, El Paso, and Amarillo, Texas are listed because they are representative of the vegetation type climate.

Source: U.S. Department of Commerce (1965).

Desert Shrub

Average annual precipitation is less than 8 inches, which may occur anytime throughout the year. January temperatures range from average minimum temperatures of 25° F to an average maximum temperature of 55° F. July temperatures typically average from 60° F (minimum) to 105° F (maximum). Frost-free periods normally last 10 or 11 months.

Southwestern Shrubsteppe

Average annual precipitation varies from 8 to 16 inches, occurring mostly between spring and fall. January temperatures range from an average minimum temperature of 25° F to an average maximum temperature of 60° F. July temperatures typically average from 60° F (minimum) to 95° F (maximum). Frost-free periods normally last 9 to 11 months.

Chaparral-Mountain Shrub

Climatic conditions are highly variable; chaparral and mountain shrubs occur where there is limited water but sunny conditions with a tolerance for wide temperature ranges. Average annual precipitation is 12 to 20 inches, occurring mostly in the spring and early summer (growing season). January temperatures range from an average minimum temperature of 25° F to an average maximum temperature of 50° F. July temperatures typically average from 50° F (minimum) to 95° F (maximum). Frost-free periods normally last 5 to 8 months.

Pinyon-Juniper

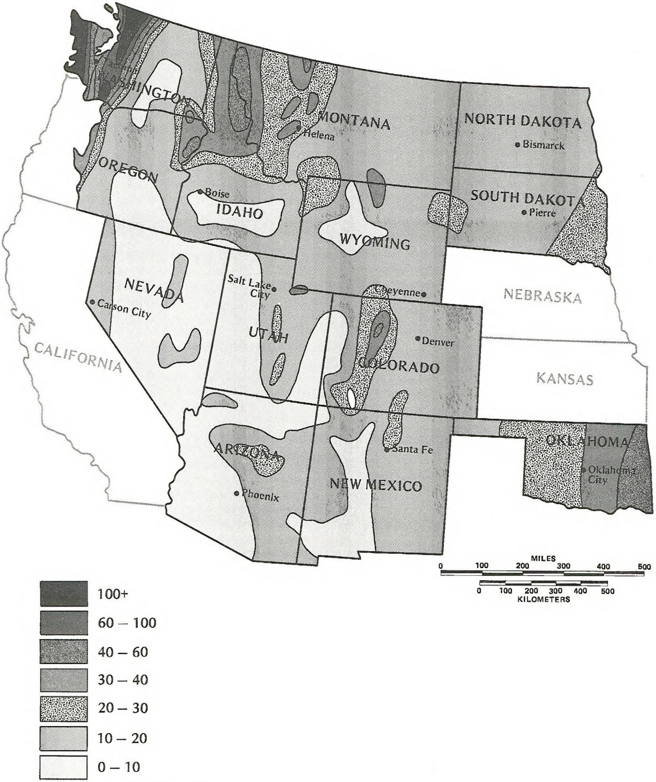
Climatic conditions are highly variable; pinyon and juniper trees grow where there is limited water but sunny conditions with a tolerance for wide temperature ranges. Average annual precipitation is normally 12 to 20 inches, occurring mostly in the summer due to convective thunderstorms. January temperatures range from an average minimum temperature of 15° F to an average maximum temperature of 50° F. July temperatures typically average from 50° F (minimum) to 90° F (maximum). Frost-free periods normally last 3 to 7 months.

Mountain/Plateau Grasslands

Climatic conditions are highly variable; average annual precipitation is normally 8 to 16 inches, occurring throughout the year. January temperatures range from an average minimum temperature of 0° F to an average maximum temperature of 32° F. July temperatures typically average from 50° F (minimum) to 85° F (maximum). Frost-free periods range from 2 to 5 months.

Plains Grasslands

Plains grassland vegetation occurs from the Canadian Border to eastern New Mexico and West Texas. Although precipitation amounts are fairly uniform, temperature conditions vary north and south of Colorado.



Source: Satterlund, Widland Watershed Management (John Wiley & Sons, 1972).

Figure 2-4
Average Annual Precipitation in the States in the Study Area

In the central and northern plains grasslands, average annual precipitation is 14 to 18 inches, occurring mostly from spring to fall as a result of convective thunderstorms. Winter precipitation is snow. January temperatures range from an average minimum temperature of 0° F to an average maximum temperature of 32° F. July temperatures typically average from 50° F (minimum) to 85° F (maximum). Frost-free periods normally last 7 months.

In the southern plains grasslands, average annual precipitation is 14 to 20 inches (but fluctuates considerably from year to year), occurring mostly from late spring to fall. Winter precipitation is relatively light snow. January temperatures range from an average minimum temperature of 20° F to an average maximum temperature of 50° F. July temperatures typically average from 65° F (minimum) to 95° F (maximum). Frost-free periods normally last 9 months.

Coniferous/Deciduous Forest

Coniferous and deciduous forest vegetation occurs in the mountains throughout the study area and along the coastal Pacific Northwest. There are three distinct forest regions: the southern Rocky Mountains (including the ponderosa pine forest of the Mogollon Rim), the northern and central Rocky Mountains, and the coastal Pacific Northwest. Microclimatic conditions make forest climates highly variable.

In the southern Rocky Mountains, average annual precipitation is 16 to 20 inches, occurring mostly from mid-summer to fall. January temperatures range from an average minimum temperature of 10° F to an average maximum temperature of 45° F. July temperatures typically average from 45° F (minimum) to 85° F (maximum). Frost-free periods normally last 3 to 7 months.

In the northern and central forests, average annual precipitation varies from 20 to 55 inches (depending mostly on elevation) and occurs mostly as snow from fall to spring (summers are dry). January temperatures range from an average minimum temperature of 0° F to an average maximum temperature of 32° F. July temperatures typically average from 40° F (minimum) to 85° F (maximum). Frost-free periods normally last 2 to 4 months.

In the Pacific Northwest, average annual precipitation ranges from 20 to 100 inches, occurring during the fall, winter, and spring; summers are dry. January temperatures range from an average minimum temperature of 20° F to an average maximum temperature of 45° F. July temperatures typically average from 50° F (minimum) to 80° F (maximum). Frost-free periods normally last 4 to 8 months. Higher elevations are wetter and colder.

Air Quality

The existing air quality throughout much of the study area is unknown; little monitoring data are available for most pollutants. However, in the undeveloped regions of the Western United States, ambient pollutant levels are expected to be near or below the measurable limits. Locations vulnerable to decreasing air quality from extensive development include immediate operation areas (milling operations, powerplants, and so on) and local population centers (automobile exhaust, residential wood smoke, and so on) Noise levels are site-specific and vary continuously. Rural noise levels should average 30 to 50 decibels A-weighted (dbA), with occasional peak levels to 90 dbA.

National ambient air quality standards (Table 2-3) limit the amount of specific pollutants allowed in the atmosphere: carbon monoxide, lead, nitrogen dioxide, ozone, sulfur dioxide, and particulate matter (total suspended particulates and inhalable particulates). State standards include these parameters, but may also be more stringent. The standards protect public health (primary standards) and welfare (secondary standards).

For many years, the particulate matter standard included all size ranges of particles (thus called total suspended particulates). Measured values were dominated by fugitive (wind blown) dust particles, which are larger than those produced in combustion processes, settle relatively quickly, and are a minimal threat to health. The Environmental Protection Agency (EPA) recognized these limitations and established new standards for particulates less than 10 microns in diameter, commonly called inhalable particulates and abbreviated PM10. The total suspended particulates (TSP) standards will be phased out over time.

Areas that consistently violate Federal standards because of human activities are classified as "nonattainment" areas and must implement a plan to reduce ambient concentrations below the maximum pollution standards. Under EPA's "Fugitive Dust Policy," areas that violate the TSP standards, but lack significant industrial particulate sources and have a population less than 25,000, are designated as "unclassified" (neither "attainment" nor "nonattainment"). "Unclassified" areas are generally exempt from having to follow the Clean Air Act offset provisions, retrofit controls, and new source control requirements established for "nonattainment" areas.

Through the Clean Air Act Amendments of 1977, Congress established a system for the Prevention of Significant Deterioration (PSD) of "attainment" and "unclassified" areas. Areas are classified by the additional amounts of nitrogen dioxide (NO_2), sulfur di-

Table 2-3

Federal Air Quality Standards (micrograms per cubic meter)

Pollutant	Averaging[1] Time	Ambient[2] Primary	Ambient[2] Secondary	Increment[3] Class I	Increment[3] Class II	Increment[3] Class III
Carbon Monoxide	8 hours	10,000	10,000	—	—	—
	I hour	40,000	40,000	—	—	—
Lead	Quarterly	1.5	1.5	—	—	—
Nitrogen Dioxide	Annual (Arith.)	100	100	2.5	25	50
Oxidants (Ozone)	I hour	235	235	—	—	—
Sulfur Dioxide	Annual (Arith.)	80	—	2	20	40
	24 hours	365	—	5	91	182
	3 hours	—	1,300	25	512	700
Total Suspended Particulates	Annual (Geom.)	75[4]	60[4]	5	19	37
	24 hours	260[4]	150[4]	10	37	75
Inhalable Particulates	Annual (Arith.)	50	50	—	—	—
	24 hours	150	150	—	—	—

[1] Short-term standards (those other than Annual and Quarterly) are not to be exceeded more than once each year, except the Federal ozone and PM10 standards. The "expected number of days" with ozone or PM10 levels above the standard is not to be exceeded more than once per calendar year.

[2] Ambient standards are the absolute maximum level allowed to protect either public health (primary) or welfare (secondary).

[3] Incremental (Prevention of Significant Deterioration) standards are the maximum incremental amounts of pollutants allowed above a specified baseline concentration.

[4] Federal TSP standards were superseded by the Federal PM10 standards, effective July 31, 1987. The TSP standards will be phased out over time.

Note: States may set standards more stringent than the Federal standards.

Sources: National Primary and Secondary Ambient Air Quality Standards (40 CFR 50 et seq., as revised, July 1, 1988). Requirements for Preparation, Adoption and Submittal of Implementation Plans (40 CFR 51.166, as revised, July 1, 1988).

oxide (SO_2), and TSP degradation that would be allowed. PSD Class I areas, predominantly National Parks and certain Wilderness Areas, have the greatest limitations; virtually any degradation would be significant (Figure 2-5). Areas where moderate, controlled growth can take place were designated as PSD Class II. PSD Class III areas allow the greatest degree of degradation.

PSD Class I regulations also address the potential for impacts to Air Quality Related Values (AQRVs). These AQRVs include visibility, odors, and impacts to flora, fauna, soils, water, and geologic and cultural structures. A possible source of impact to AQRVs is acid precipitation.

Most of the study area has been designated as either "attainment" or "unclassified" for all pollutants. All BLM-administered lands are classified PSD Class II. Table 2-4 identifies by State the number of suspected and known "nonattainment" areas for each pollutant.

Particulate matter concentrations are expected to be higher near industrial areas, towns, and unpaved roads. Inhalable particulate levels are high in areas with significant combustion sources (urban areas, industrial facilities, residential wood smoke). Thirty-five areas are believed to exceed the Federal standards, and 43 areas are conducting monitoring to determine whether the standards are exceeded.

Similarly, TSP levels may be high because of wind-blown dust in arid locations, or from combustion sources. Eighty-four areas exceed the public health standard: 92 areas exceed the public welfare standard.

Source: U.S. Environmental Protection Agency, 1979.

Figure 2-5
Air Quality Class I Areas of the States in the Study Area

High sulfur dioxide concentrations occur primarily near coal-fired powerplants, smelters, refineries, or other industrial facilities that process materials containing sulfur. Thirty-one areas exceed the public health standard; 33 areas exceed the public welfare standard.

Two locations exceed the nitrogen dioxide standards: central Denver, Colorado; and Boise-Ada County, Idaho.

High carbon monoxide and ozone concentrations are associated mostly with transportation fuel and exhaust gases, and hydrocarbon processing (refineries). The study area contains 29 carbon monoxide and 30 ozone "nonattainment" areas.

Since the introduction of lead-free gasoline, lead concentrations have decreased significantly. Only Shoshone County, Idaho, and Bernalillo, Eddy, and Lea Counties, New Mexico, exceed the Federal standards.

Eighty-five PSD Class I areas have been designated in the study area. Most are located in the mountainous regions, but many may be found at lower elevations. Table 2-5 identifies the number of PSD Class I areas by managing agency for each State.

Visibility and acid precipitation are monitored at isolated locations in the study area.

The following analysis region descriptions are necessarily broad generalizations of very complex air quality conditions. Because this information cannot be extrapolated throughout each analysis region, site-specific monitoring is necessary to determine local conditions.

Sagebrush

With few isolated major industrial facilities and even fewer major cities, this analysis region has the best air quality in the study area. Particulate matter concentrations may be high occasionally because of transitory windblown dust. Reno, Nevada, on the

Table 2-4
Number of Suspected and Known Nonattainment Areas in the Study Area

State	PM10				Nonattainment Pollutant					
	Group		TSP		SO_2		NO_2	CO	03	PB
	I	II	1'	2'	1'	2'				
Arizona	6	7	10	10	10	10	—	5	6	—
Colorado	6	11	11	8	—	—	1	4	1	—
Idaho	4	1	6	6	3	3	1	—	—	1
Montana	6	6	11	11	5	8	—	4	—	—
Nevada	2	1	11	11	6	6	—	3	3	—
New Mexico	1	8	7	9	6	4	—	3	4	2
North Dakota	—	—	2	2	—	—	—	—	—	—
Oklahoma	—	1	6	8	—	—	—	1	6	—
Eastern Oregon	1	2	1	2	—	—	—	—	—	—
South Dakota	—	1	1	2	—	—	—	—	—	—
Utah	2	—	1	1	1	1	—	1	1	—
Washington	6	2	8	9	—	—	—	5	6	—
Wyoming	1	1	1	4	—	—	—	—	—	—
Study Area Totals	**35**	**41**	**76**	**83**	**31**	**32**	**2**	**26**	**27**	**3**

NAAQS - National Ambient Air Quality Standards
PM10 I - Inhalable Particulate Matter NAAQS (less than 10 microns in size); Group I Area (high probability of not attaining the standards)
PM10 II - Inhalable Particulate Matter NAAQS (less than 10 microns in size); Group II Area (monitoring required to determine attainment status)
TSP 1' - Primary (public health) Total Suspended Particulate NAAQS
TSP 2' - Secondary (public welfare) Total Suspended Particulate NAAQS
SO_2 1' - Primary (public health) Sulfur Dioxide NAAQS
SO_2 2' - Secondary (public welfare) Sulfur Dioxide NAAQS
NO_2 - Nitrogen Dioxide NAAQS
CO - Carbon Monoxide NAAQS
03 - Ozone (photochemical oxidant) NAAQS
PB - Lead NAAQS

Source: 40 CFR 52 et seq. (Revised as of July 1, 1988).

Table 2-5

Number of PSD Class 1 Areas in the Study Area

State	USDA-Forest Service	USDI-National Park Service	USDI-Fish and Wildlife	Tribal Governments
Arizona	8	4	—	—
Colorado	8	4	—	—
Idaho[1]	3	2	—	—
Montana[2]	7	2	3	3
Nevada	1	—	—	—
New Mexico	5	2	2	—
Eastern Oregon[3]	11	1	—	—
South Dakota	—	2	—	—
Utah	—	5	—	—
Washington	5	3	—	1
Wyoming[4]	5	2	—	—
Study Area Totals	**53**	**27**	**5**	**4**

[1] Hells Canyon Wilderness is also in Eastern Oregon. Selway-Bitteroot Wilderness is also in Montana. Yellowstone National Park is also in Montana and Wyoming.

[2] Selway-Bitteroot Wilderness is also in Idaho. Yellowstone National Park is also in Idaho and Wyoming.

[3] Hells Canyon Wilderness is also in Idaho.

[4] Yellowstone National Park is also in Idaho and Montana.

Source: Bureau of National Affairs, Inc. (1989).

west, and Salt Lake City, Utah, on the east, have high concentrations of particulate matter, carbon monoxide, and ozone (Salt Lake City also has high levels of sulfur dioxide).

Desert Shrub and Southwestern Shrubsteppe

Las Vegas, Nevada, and Phoenix, Arizona, have high particulate matter, sulfur dioxide, carbon monoxide, and ozone concentrations associated with urban industrial and transportation pollution sources. Rural areas generally have good air quality, which may occasionally be degraded by pollution from urban areas (including Southern California), isolated powerplants, copper smelters, and (under certain meteorologic conditions) industrial facilities in northern Mexico.

Chaparral-Mountain Shrub and Mountain/Plateau Grasslands

These analysis regions are distributed throughout the study area and do not exhibit unique air quality characteristics. High TSP concentrations may occur because of wind-blown dust, but other elevated air pollution concentrations are limited to locations near industrial or urban development.

Pinyon-Juniper

Albuquerque, New Mexico, is the only major urban area in this analysis region. High concentrations of particulate matter, carbon monoxide, ozone, and occasionally lead may be found there. Like the sagebrush analysis region, rural areas have some of the best air quality in the Nation. Local degradation caused by isolated powerplants and occasional high concentrations of TSP as a result of wind-blown dust may occur. Ozone levels may also be intermittently high, but the cause is unknown. Elevated ozone concentrations may be a result of long-range transport from urban areas, subsidence of stratospheric ozone, or photochemical reactions with natural hydrocarbons. The true reason for elevated ozone values is uncertain.

Plains Grasslands

High concentrations of particulate matter, nitrogen dioxide, carbon monoxide, and ozone are present in Denver, Colorado. Most of the rural areas have good air quality, except for moderate degrada-

tion near industrial facilities. High TSP concentrations as a result of wind-blown dust are common.

Coniferous/Deciduous Forest

Air quality is generally good throughout the Rocky Mountains. Isolated areas with high winter inhalable particulate concentrations are common because of a combination of residential wood-burning and mountain valley inversions. Boise, Idaho, has elevated particulate matter and nitrogen dioxide concentrations.

In the Pacific Northwest, the Seattle-Tacoma, Washington, area has high particulate matter, carbon monoxide, and ozone levels. Because of the extensive amount of forest and agricultural burning that occurs, elevated concentrations of inhalable particulates are seasonally common.

Geology and Topography

The geology of the EIS program States varies considerably. The 13 Western States extend from the high plains in the East where thick alluvial deposits overlie fractured sedimentary rocks, across the granitic and metamorphic rocks of the Rocky Mountains and the thick sedimentary sequences in the Wyoming Basin and Colorado Plateau, to the thick lava sequences of the Columbia Plateau and the thick alluvial valley fills and bedrock ridges of the Basin and Range region in the West (Figure 2-3).

Western lands contain a variety of metals and minerals, in addition to coal, oil shale, and oil and gas reserves. Other geologic resources include geothermal deposits, radionuclides, and building materials (such as sand, gravel, clay, pumice, and stone).

The topography of the Western States varies from the nearly level or gently rolling lands of the Great Plains to the steep and rugged regions of the Rocky Mountains. Elevations range from near sea level in the deserts of the Southwest to above 14,000 feet in the alpine habitats of the Rockies. The plateau areas have been subjected to stream incision and show extensive local relief (for example, the Grand Canyon and Snake River Canyon). The mountains have been uplifted and folded and also show evidence of stream dissection. Alluvial deposits occur along the courses of major rivers and streams in valleys, including the arid and semi-arid basins of the Southwest.

Sagebrush

The sagebrush analysis region occupies many of the valley areas in the Basin and Range region between the Rocky Mountains on the east and the Sierra Nevadas on the west, as well as portions of the Columbia Plateau, the northern Colorado Plateau, and the Wyoming Basin (Garrison et al. 1977). Elevations vary from 2,000 feet above sea level along the Snake River Plain to as much as 7,000 feet above sea level in the Basin, Range, and Colorado Plateau regions (Hunt 1973). Much of this intermountain area is characterized by numerous separated sediment-filled interior basins, with only a small portion of these basins draining to the sea. Except for the Snake River and its tributaries in the Snake River Plain, streams in this region are generally intermittent. In Nevada, the discontinuous ranges of the Basin and Range provinces rise steeply and disrupt the semiarid, sagebrush-covered valleys.

Desert Shrub

The desert shrub analysis region is a composite of various desert shrublands and includes the salt flats of the Great Salt Lake, the southwestern desert plains and plateaus, the western one-third of the Great Basin, the eastern edge of the Great Basin, parts of Wyoming and Big Horn Basins, and parts of the Colorado Plateau (Garrison et al. 1977). Extremely arid continental deserts lie south of the Rocky Mountains. This analysis region includes parts of the American Desert in Arizona, Nevada, and Utah, and several isolated, small desert basins in eastern Oregon, southern Idaho, and western Colorado and Wyoming. The topography is characterized by extensive plains from which isolated mountains and buttes rise abruptly. Elevations range from near sea level to 11,000 feet above sea level in some mountain ranges. The few larger permanent rivers include the Colorado, Shoshone, and Snake Rivers. In much of the region, dry washes fill with water only after infrequent rains.

Southwestern Shrubsteppe

The southwestern shrubsteppe analysis region occurs south of the Rocky Mountains. This region is made up of relatively large blocks of almost-level desert plains isolated between roughly parallel low mountains of the Sonoran Desert, the Big Horn, and the Maricopa ranges in Arizona, and across the Mexican Highlands through southern Arizona and New Mexico. This analysis region occurs at a lower altitude than the pinyon-juniper ecosystem and is often referred to as the semidesert grass-shrub type (Garrison et al. 1977). In this region, materials eroded from the mountains have formed broad alluvial fans that coalesce into large plains. Consolidated and semi-consolidated rocks predominate in this region.

Chaparral-Mountain Shrub

The chaparral-mountain shrub analysis region occupies mountain areas beginning at 5,000 feet in northern latitudes to 6,500 feet in southern latitudes. This region occurs as a narrow transition area between the arid lower elevation zones, similar to the desert shrub, southwestern shrubsteppe, and sagebrush ecosystems, and those of the higher precipitation, higher elevation regions. The chaparral-mountain shrub analysis region is generally a transition zone between the pinyon-juniper and coniferous/deciduous forest ecosystems. Slopes in these regions range from moderate to steep. The geology varies from the sedimentary rocks of the southwestern Colorado Plateau to the faulted igneous metamorphic ranges of the Basin and Range provinces, and the lower slopes of the Rocky Mountains.

Pinyon-Juniper

The pinyon-juniper analysis region occupies the mid elevations in the Upper and Lower Basin and Range Provinces with its intermingled basins and mountains, and areas within the Colorado Plateau, where it is often adjacent to sagebrush and chaparral-mountain shrub areas. Juniper usually occupies rockier and rougher terrain than sagebrush (Garrison et al. 1977). While sagebrush is common on the plains, terraces, and gentle portions of plateaus, the pinyon-juniper region tends to occupy the upslope contiguous sites of eroded and rough dissections.

Mountain/Plateau Grasslands

The mountain/plateau grasslands consist of noncontiguous areas of moderate to higher elevation grassland scattered through the northern, central, and southern Rocky Mountains, and the Palouse grasslands of the Columbia Plateau. They occur at elevations ranging from 3,000 to 9,000 feet and occupy a variety of topographical positions from level areas or valley floors, to alluvial benches and foothills, to steep mountain slopes.

Plains Grasslands

The plains grassland region, also known as the Great Plains, occurs on a broad belt of high land that slopes gradually eastward and down from an altitude of 3,000 feet at the western edge to an altitude of 900 feet in Texas, where it gives way to the prairie ecosystem. The plains grasslands region is characterized by rolling plains and tablelands of moderate relief and includes the areas known as the Great Plains and Wyoming Basin. The most striking feature of the region is the phenomenal flatness of its interstream areas, which make up a great expansive flood plain or alluvial slope (Forb 1963).

Coniferous/Deciduous Forest

Coniferous and deciduous forests occur throughout the Rocky Mountains and higher elevations (above 8,000 feet) of the Colorado Plateau, the Upper and Lower Basin and Range Provinces, and the Columbia Plateau. The forests may occur on steep mountainsides or canyon walls, or on relatively level plateaus of sufficient elevation. Topographical variation plays an important role in the occurrence of this zone. For example, north-facing slopes maintain cooler temperatures and retain more moisture than do south-facing slopes. Coniferous forests may find suitable growing conditions on north-facing slopes, while directly opposite on a south-facing slope, oakbrush or sagebrush, which tolerate drier conditions, will be found. This leads to very patchy distribution in some areas. Coniferous and deciduous forests may also extend below customary elevational limits in narrow, high-walled canyons that shade the bottom and promote cold-air drainage.

Soils

Soils in the program area are quite diverse, ranging from the arid salty soils of the southwest and clayey glaciated plains of Montana to the loamy intermountain valleys and rocky, often barren, alpine regions of the Rocky Mountains.

Soil development and formation is controlled by five soil-forming factors: (1) climate, in which temperature and precipitation are the most influential forces in the soil-forming process; (2) living organisms, particularly native vegetation, as well as animals and microorganisms; (3) nature of the parent material, including texture, structure, and chemical and mineralogical composition; (4) topographic location, which can quicken or delay the climatic factor; and (5) the length of time materials are subjected to the weathering process (Brady 1974).

These interrelated factors have contributed to the identification of five major soil orders (Figure 2-6) in the 13 Western States:

> Entisols are mineral soils that lack profile development (soil horizons) and are often called "young soils" because of this lack of pedogenic maturation. Entisols can include recent alluvium, sands, soils on steep slopes, and shallow soils. They can be quite productive; however, shallow depth, high clay content, and low plant

available moisture can limit the productivity of these soils. Entisols primarily support rangeland vegetation; but in areas of higher precipitation, they will support trees. Entisols predominate in eastern Montana and western Colorado.

Inceptisols are mineral soils that have some profile development and have at least one horizon. These are also "young soils" but have experienced higher weathering and soil-forming processes than the Entisols. These soils represent an extensive variety of settings, and no description can generalize this order. Inceptisols may form from sandstone or volcanic ash on steep mountain slopes or depressions, on top of mountain peaks, or next to rivers. In the northwest, these soils provide not only some of the best timber-producing lands, but also support rangelands. Inceptisols are the dominant soils in northern Idaho and parts of Washington.

Aridisols are mineral soils that have developed in dry regions, are light colored, low in organic matter, and may have accumulations of soluble salts and lime. The lower the precipitation, the more likely these accumulations are to be near the surface. The vegetation found on Aridisols are important contributors to the western livestock industry. These soils predominate in central Wyoming, southern Idaho, across Nevada, and much of Arizona.

Mollisols are mineral soils that have thick, dark-colored surface horizons rich in organic matter, and are very fertile. They have developed primarily under grassland vegetation used extensively for livestock grazing on the western public lands. Mollisols are one of the most productive soils in the EIS area. They are predominant in North and South Dakota, northern Montana, and eastern Oregon.

Alfisols are mineral soils that have developed in cool, wet regions, usually under a forest canopy, and have significant accumulation of clay. These soils are generally quite productive and are important producers of commercial timber. Alfisols occur in the mountains of western Montana, western Wyoming, and central Colorado.

Sagebrush

In Washington and eastern Oregon, the sagebrush analysis region consists mainly of Mollisols with black, friable, organic surface horizons and a high pH. In the Great Basin and part of the Wyoming Basin, soils of this region are Aridisols with pedogenic horizons, a low organic matter content, and accumulations of various salts in some places. The remaining soils of the sagebrush region on the Colorado Plateaus province are Aridisols and Mollisols. Aridisols dominate the basin and lowland areas and are dry throughout most of the year; Mollisols are found at higher elevations and are rich in organic matter. Basicity of Mollisols is high, and the soils remain soft when dry. Narrow bands of Entisols lie in stream flood plains. Salt flats, as well as playas, are extensive in the lower parts of the basins that have interior drainage.

Desert Shrub

The soils of the desert shrub analysis region are primarily Aridisols, found in the Great Basin and on southwestern desert plains and plateaus. They are low in organic matter but may support vegetation suitable for livestock grazing. Entisols as well as Aridisols may be found in the Wyoming basin and on the Colorado Plateaus. Entisols occur on some of the older alluvial fans and terraces, as well as in the better drained basins of the desert region.

Southwestern Shrubsteppe

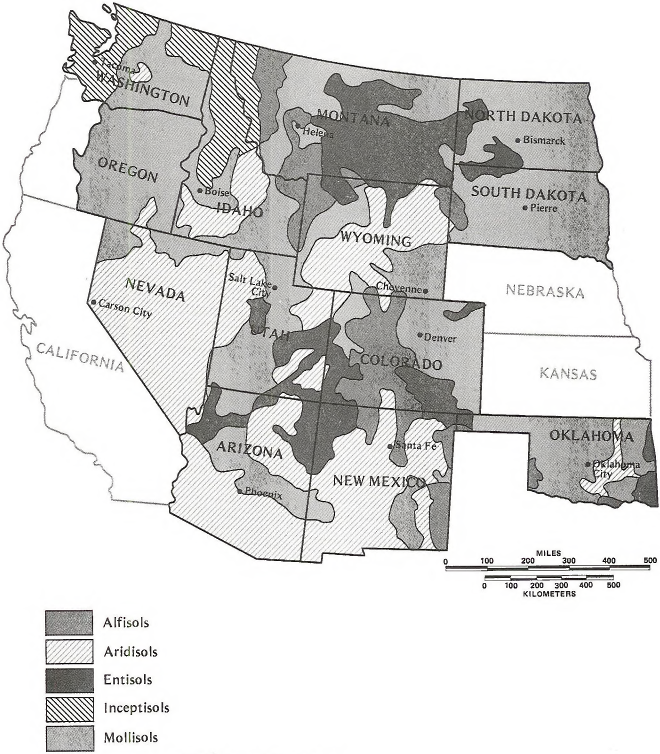
The soils of the southwestern shrubsteppe analysis region are typically Aridisols. The region's excessive heat and low rainfall are the primary mechanisms for Aridisol formation. Organic matter is present, although in low amounts. In local areas where conditions permit, Mollisol and Entisol soils have developed.

Chaparral-Mountain Shrub

In the Rocky Mountains, the chaparral-mountain shrub analysis region contains Mollisols that may have a subsurface horizon of clay. In the southern edge of the Basin and Range province and the upper Gila Mountains, Aridisols that have a low content of organic matter, and a horizon of accumulated clay may be found.

Pinyon-Juniper

In the Basin and Range province, the pinyon-juniper analysis region includes Aridisols, which have a moderate-to-low organic matter content and may have accumulations of carbonates. In the Colorado Plateaus, the woodland contains Aridisols; Entisols, which have no pedogenic horizons; and Mollisols, which have an organic surface horizon and a high pH.



Source: Buckman, H.O. and MN.C. Brady, 1969. The Nature and Properties of Soils. The MacMillian Company, Collier-MacMillan Limited, London.

Figure 2-6
Major Soil Orders of the States in the Study Area

Mountain/Plateau Grasslands

Aridisols, which can be found in all basins and lowland areas, as well as in the deserts and plains, are the dominant soil type of the plateau analysis region. Some Entisols are found in narrow bands in the Colorado Plateau stream flood plains; Aridisols and Mollisols with developed horizons are located in central Colorado. In the Yellowstone River area of south-central Montana, the grassland soils are Entisols with no horizon development. Soils in the grasslands of the northern Rocky Mountains are Mollisols. Mollisols are also the principal soils of the Columbia Plateau's foothills or Palouse hills.

Plains Grasslands

Soils in the plains grasslands analysis region are varied. Mollisols and Entisols are found from the Canadian border to the southern boundary of the region in Texas. The Wyoming basin has extensive alluvial deposits in stream flood plains and in fans at the foot of mountains.

Coniferous/Deciduous Forest

Soils of the coniferous/deciduous forest analysis region vary tremendously. Soils along the western edge of the Columbia Plateau and the east slope of the Cascade Mountains include Mollisols, Inceptisols, and Entisols. At the northern edge of the Columbia Plateau and in much of the northern Rocky Mountains, these forests occur primarily on Inceptisols. Soils of the rest of these areas are largely Alfisols and Entisols. In the middle and southern Rocky Mountains, coniferous forests occur on Mollisols, Entisols, and Alfisols. Coniferous forests in the Gila Mountains are largely Mollisols.

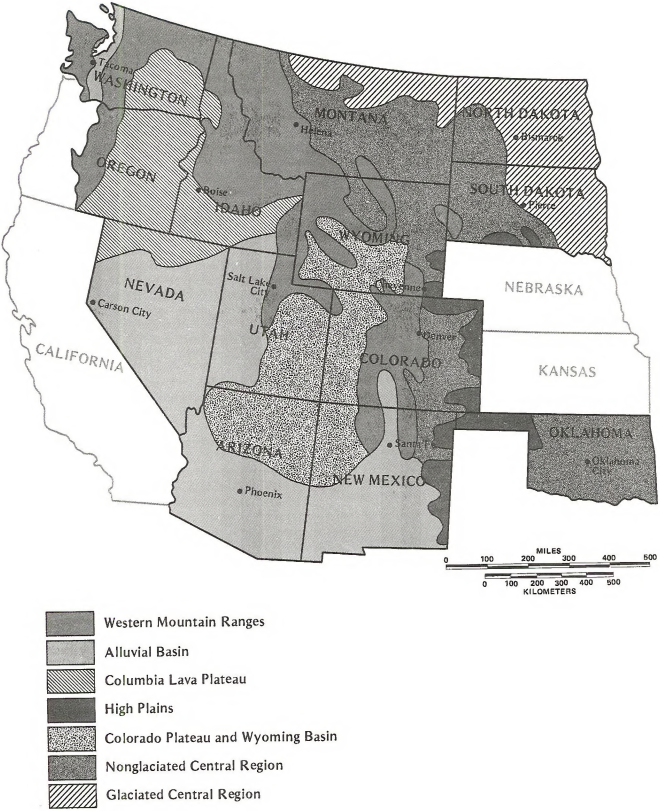
Aquatic Resources

Water availability varies greatly in the Western States, from abundant in the mountains to extremely scarce in the desert. Mountainous areas have natural lakes and large, deep reservoirs. Water supply is low to moderate in the tall- and shortgrass prairies. Surface lakes, shallow wells, and streams are used for irrigation and livestock watering. Intermittent waters, such as prairie potholes, are important breeding grounds as well as migration stops for waterfowl and other wetland species. Many areas of the southwest and intermountain areas are characterized by low precipitation and may have limited water sources. Surface water for irrigation and livestock comes from the numerous reservoirs on major rivers, smaller streams and lakes, ponds, and springs.

The ground-water resources of the BLM lands include outcropping, unconsolidated geologic formations with unconfined water tables (including alluvial valley deposits), and confined aquifers (generally consolidated rock) overlain by relatively impermeable formations (Figure 2-7, Table 2-6). Confined aquifers receive recharge from the surface where they are exposed, typically in upland, mountainous areas. Because of the overlying low permeability formations and the lack of infiltration from precipitation, confined aquifers in the EIS region rarely receive recharge in the lower elevation plateaus and desert plains (Table 2-7). Unconfined aquifers may have water tables ranging in depth from near the surface to more than 100 feet, as recharge from the surface may be minimized by extensive evapotranspiration and low precipitation input. Water tables of unconfined aquifers may approach and intersect the surface along the channels of major permanent streams in the alluvial aquifers. Ground water may be abundant in those valleys where deep alluvium increases aquifer storage capacity. Where available, ground water is used for agricultural irrigation, livestock watering, and population water supplies. Ground water is used extensively in the West as a domestic water supply ranging from 90 percent of the population in Arizona, Idaho, Nevada, and New Mexico to less than 50 percent in Colorado, Oklahoma, and Oregon. These water sources vary in depth and aerial extent, and it is not uncommon for BLM lands to be above or near them.

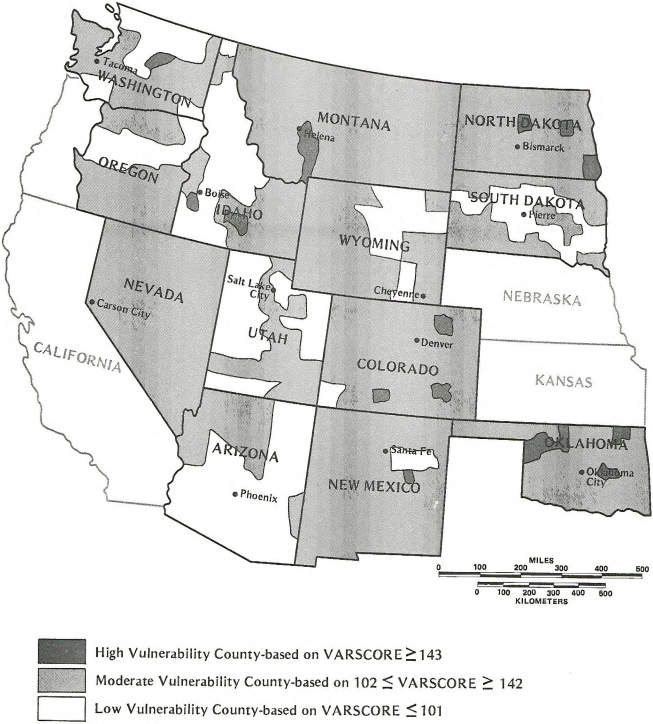
Recent ground water studies have shown a greater number of water supplies to be contaminated with pesticides. Generally, shallower supplies are at greater risk than deeper ones. Contaminants have been shown to include a number of insecticides and herbicides. It is generally recognized that these pesticide contaminants originate from agricultural lands and poor application practices.

The EPA in response to the concern for ground water contamination developed a rating system to delineate ground-water contamination vulnerability. This system, known as DRASTIC (Aller et al. 1985), has been used nationwide and uses factors of depth to water, net recharge, aquifer media, soil media, topography, impact to unsaturated zone, and gross hydraulic conductivity to identify potential vulnerability areas. Figure 2-8 shows those vulnerability areas for the EIS area. Most of the areas in Figure 2-8 are in the low and moderate vulnerability category. However, the information presented in EPA (1987) was constructed with very general data and may over or underestimate vulnerability. For example, areas having higher than normal recharge patterns would not be identified. Such areas would have a higher vulnerability than is shown on Figure 2-8. Care should be taken to make sure the DRASTIC system is applied properly at the site-treatment level.



Source: Heath, 1984

Figure 2-7
Ground-water Regions of the States in the Study Area



Source: U.S. Environmental Protection Agency, 1987.

Figure 2-8
Categories of Ground-water Vulnerability of the States in the Study Area

Table 2-6

Summary of the Principal Physical and Hydrologic Characteristics of the Ground-Water Regions of the States in the Study Area

	Components of the System											Characteristics of the Dominant Aquifers																		
												Water-Bearing Openings					Composition		Storage and Transmission Properties						Recharge and Discharge Conditions					
	Unconfined Aquifer			Confining Beds		Confined Aquifers			Presence and Arrangement			Primary			Secondary		Degree of Solubility		Porosity			Transmissivity			Recharge			Discharge		
	Hydrologically insignificant	Minor aquifer or not very productive	Dominant aquifer	Hydrologically insignificant	Interlayered with aquifers	Hydrologically significant	Not highly productive	Multiple productive aquifers	Single unconfined aquifer	Two interconnected aquifers	Complex interbedded sequence	Pores in unconsolidated deposit	Pores in semiconsolidated rocks	Tubes and cooling cracks in lava	Fractures and faults	Solution-enlarged openings	Insoluble	Mixed soluble and insoluble	Large (greater than 0.2)	Moderate (0.01-0.2)	Small (less than 0.01)	Large (greater than 2,500 m^2day^{-1})	Moderate (250-2,500 m^2day^{-1})	Small (25-250 m^2day^{-1})	Uplands between streams	Losing streams	Leakage through confining beds	Springs and surface seepage	Evaporation and basin sinks	Into other aquifers
Western Mountain Ranges	—	X	—	X	—	—	X	—	—	X	—	X	—	—	X	—	X	—	—	X	—	—	—	X	X	X	—	X	—	—
Alluvial Basins	—	—	X	—	X	—	—	X	—	—	X	X	—	—	—	—	X	—	X	—	—	X	—	—	—	X	—	—	X	X
Columbia Lava Plateau	—	X	—	—	X	—	—	X	—	—	X	X	—	X	X	—	X	—	—	—	X	X	—	—	—	X	—	X	—	—
Colorado Plateau and Wyoming Basin	X	—	—	—	X	—	—	X	—	—	X	—	X	—	X	—	X	—	—	—	X	—	—	X	X	—	X	X	—	—
High Plains	—	—	X	X	—	X	—	—	X	—	—	X	—	—	—	—	X	—	X	—	—	X	—	—	—	X	—	X	—	—
Nonglaciated Central Region	—	X	—	—	X	—	—	X	—	—	X	—	X	—	X	X	—	X	—	—	X	—	X	—	X	—	X	X	—	X
Glaciated Central Region	—	X	—	—	X	—	—	X	—	—	X	X	X	—	X	X	—	X	—	X	—	—	X	—	—	—	X	—	—	X

Source: Heath, 1984.

Table 2-7

Common Ranges on the Hydraulic Characteristics of Ground-Water Regions of the States in the Study Area

Region	Geologic Situation	Common Ranges in Hydraulic Characteristics of the Dominant Aquifers							
		Transmissivity		Hydraulic Conductivity		Recharge Rate		Well Yield	
		m^2 day^{-1}	ft^2 day^{-1}	m day^{-1}	ft day^{-1}	mm yr^{-1}	in. yr^{-1}	m^3 min^1	gal min^1
Western Mountain Ranges	Mountains with thin soils over fractured rocks, alternating with narrow alluvial and, in part, glaciated valleys	-100	5-5,000,000	0.0003-15	0.001-50	3-50	0.1-2	0.04-0.4	10-100
Alluvial Basins	Thick* alluvial (locally glacial) deposits in basins and valleys bordered by mountains	20-20,000	2,000-200,000	30-600	100-2,000	0.03-30	0.001-1	0.4-20	100-5,000
Columbia Lava Plateau	Thick sequence of lava flows interbedded with unconsolidated deposits and overlain by thin soils	2,000-500,000	20,000-5,000,000	200-3,000	500-10,000	5-300	0.2-10	0.4-80	100-20,000
Colorado Plateau and Wyoming Basin	Thin* soils over fractured sedimentary rocks	0.5-100	5-1,000	0.003-2	0.01-5	0.3-50	0.01-2	0.04-2	10-1,000
High Plains	Thick alluvial deposits over fractured sedimentary rocks	1,000-10,000	10,000-100,000	30-300	100-1,000	5-80	0.2-3	0.4-10	100-3,000
Nonglaciated Central region	Thin regolith over fractured sedimentary rocks	300-10,000	3,000-100,000	3-300	10-1,000	5-500	0.2-20	0.4-20	100-5,000
Glaciated Central region	Thick glacial deposits over fractured sedimentary rocks	100-2,000	1,000-20,000	2-300	5-1,000	5-300	0.2-10	0.2-2	50-500

Note: All values are rounded to one significant figure.

* An average thickness of about 5 was used as the break point between thick and thin.

Source: Heath, 1984.

Sagebrush

Surface Water

Water resources associated with sagebrush communities generally are limited because of the low precipitation in much of this region. Streams and rivers typically originate in higher elevation zones and flow through more arid sagebrush regions. Stream systems that are relatively stable (without incised channels) in soils with good water-holding capacity can store large quantities of water during episodes of overbank flooding, resulting in local ground-water development. This stored water is later released when upstream supplies are limited. Incised streams may often not provide significant localized ground-water systems and often result in ephemeral conditions. Other perennial or intermittent surface streams may be present because of significantly large ground-water systems. Other natural surface water sources are springs and seeps supplied by a range of ground-water systems. Some may provide very persistent water from year to year, while others may dry up in late summer or during drought periods. Ponds and lakes seldom occur naturally in sagebrush regions and are more often associated with spring and reservoir development.

Water quality is generally acceptable for most wildlife and livestock use, with pH above 7.0, high alkalinity, and elevated dissolved solids (greater than 200 milligrams per liter (mg/L). Usually, temperature and sediment are the limiting water quality criteria for fisheries. Temperature extremes respond to the air temperature, topographic and vegetative shading, and the associated ground-water system. Sediment sources include adjacent rangeland, stream banks, and in-channel deposits. Sediment also causes a problem for agriculture by filling diversions, ponds, and canals.

Sagebrush watershed systems routinely undergo extreme flooding. Unprotected areas without vegetation can yield large amounts of water. Where runoff water is concentrated, erosional rills and eventual gully systems can develop, impeding transportation, draining ground water, and producing problems with aesthetic quality.

Water use in sagebrush regions is limited because of the limited water supply. Typical uses include livestock and wildlife watering, irrigation, domestic use, passive and active recreation, and fisheries.

The Basin and Range region is the driest in the United States, with large parts of it being classified as semiarid and arid. Annual precipitation in the valleys in Nevada and Arizona ranges from 4 to 16 inches. Most of the ground-water resources receive their recharge from rainfall on adjacent, higher elevation mountains and ridges. Surface streams originate in these higher rainfall areas and flow through the sagebrush region. Because of the very thin cover of unconsolidated material in the mountains in the Basin and Range areas, precipitation runs off rapidly down the valleys and out onto the fans, where it infiltrates into the alluvium. The center of many basins consists of flat-floored, vegetation-free areas onto which ground water may discharge and on which overland runoff may collect during intense storms.

Precipitation in the sagebrush portion of the Columbia Plateau provides generally small and marginal sources of water. The Columbia, Snake, and Colorado Rivers are the principal surface waters and provide hydroelectric power, as well as reservoir resources. The water sources of the Columbia and Snake Rivers are especially important because they support the extensive irrigation projects that support agricultural crops and livestock in this area.

Ground Water

Ground-water resources in the sagebrush analysis region consist of areas within the central and northern Basin and Range Region, the western Columbia Plateau, most of the Wyoming Basin, and portions of the Colorado Plateau. Ground water is a major source of water in the Basin and Range region. Many of the valleys in this region have been developed for agriculture. Because of the dry climate, agriculture requires extensive irrigation. This irrigation water is obtained from ground-water wells drawing from the sand and gravel deposits in the valley alluvium.

The Colorado Plateau and Wyoming Basin areas are dry, sparsely populated regions in which most water supplies are obtained from the perennial streams that flow from the bordering mountains. Thin unconsolidated deposits of alluvium capable of yielding small-to-moderate supplies of ground water occur along valleys and major streams. Less than 5 percent of the water needs are supplied by ground water, and the development of even small ground-water supplies requires detailed knowledge of the rock units and their structure, as well as the chemical quality of the water.

Mineralized or saline water (greater than 1,000 mg/L of dissolved solids) is widespread as a result of the solution of gypsum and halite beds, especially within lower elevation shales and siltstones. Freshwater (less than 1,000 mg/L dissolved solids) occurs only in the most permeable sandstones and limestones. Because of the large surface relief and dip of the aquifers, wells even for domestic or small livestock must penetrate to depths of a few hundred yards in much of the area. Water is plentiful in the Snake River area of the Columbia Plateau and is used extensively for irrigation (USDA 1981). Small reservoirs supply additional water for irrigation and

recreation; a few terminal lakes are used mainly for recreation. In the Colorado Plateau, the sandstone deposits provide the principal sources of ground water in the region and contain water in fractures developed along bedding planes and across the beds in interconnected pores (Heath 1984). Much of the Columbia Plateau is in the rain shadow east of the Cascades, and as a result, receives only 8 to 48 inches of precipitation annually. The areas that receive the least rain in the Plateau are the sagebrush regions immediately east of the Cascades and the plains area of the Snake River.

Recharge to the ground-water system depends on several factors, including the amount and seasonal distribution of precipitation and the permeability of surficial materials. Most precipitation occurs in the winter and thus coincides with the cooler, nongrowing season when conditions are most favorable for recharge. Considerable recharge also occurs by infiltration of water from streams that flow onto the plateau from the adjoining mountains. Discharge from the ground-water system occurs as seepage to streams, as spring flow, and by evapotranspiration in areas where the water table is at or near the land surface. The famous Thousand Springs and other springs along the Snake River canyon in southern Idaho are among the most spectacular displays of ground-water discharge in the world. The alluvial valley fill deposits in the Basin and Range area also provide a major source of water for agriculture. Elsewhere in this region, ground-water supplies are limited and largely untapped. Shallow wells commonly contain large amounts of salt.

Desert Shrub

Surface Water

Annual precipitation in this region averages between 5 to 10 inches, although some desert areas may average less than 4 inches of annual precipitation. Surface water resources are limited because of the meager rainfall, which is only 20 percent of the frost-free season evaporation potential (Garrison et al. 1977). Like the sagebrush ecosystem, the few larger surface streams that flow through the desert shrub ecosystem originate in higher rainfall, higher elevation foothills and mountain areas. The large surface streams have many dams and reservoirs to help supply irrigation water for agriculture in this region, particularly the Colorado, Snake, and Gila Rivers. The Colorado River has acquired a higher salinity in recent years, so careful evaluation of present and future watershed management practices will determine the magnitude and duration of this water quality issue. The water resources of this region offer a unique habitat to wildlife in an otherwise arid region.

Surface water is very important in these areas and is usually dependent upon water originating from higher elevation watersheds or large ground-water systems. Perennial river systems are uncommon. Most watershed drainages are ephemeral, flowing only during periods of extreme precipitation. Where river systems are absent, the only permanent source of water occurs as seeps, springs, and wells. Other water sources resembling ponds are supplied by occasional precipitation and occur naturally and artificially. Flooding occurs in winter, spring, and summer; flash flooding is common in summer.

Surface water quality is generally poor, limited by high dissolved solids, sediment, and high temperature. Surface drinking water supplies are limited to supporting wildlife and livestock.

Riparian habitats are usually limited to those areas having perennial surface water. Stream channels are generally low gradient with fine-textured substrates. Typical riparian vegetation consists of saltcedar, certain species of cottonwood and willow, and grass-like species.

Ground Water

The absence of extensive surface water resources emphasizes the importance and dependence upon the ground-water resources in this region. Irrigation water is obtained from large springs in Nevada and local wells in various areas. These water sources are also used to supply livestock with drinking water year-round. Ground-water quality is variable; however, most potable water systems make use of these subsurface supplies. The ground water of this region, like portions of the sagebrush region, is concentrated in the alluvial valley deposits and sedimentary basin fills. Extensive ground-water withdrawals from these alluvial deposits result in their compaction and consequent subsidence in the ground surface. In areas of southern Arizona, more than 13 feet of subsidence have been observed (Heath 1984). Additionally, the dependence on ground-water resources in this ecosystem has been aggravated by the need to preserve unique and critical ground-water pools and habitats, such as that of the desert pupfish.

Southwestern Shrubsteppe

Water resources in the southwestern shrubsteppe region are very limited because of the low precipitation. Surface water is very important in these areas and is usually dependent upon water originating from higher elevation watersheds or large ground-water systems. Perennial river systems are uncommon. Most watershed drainages are ephemeral, flowing only during periods of extreme precipitation.

Where river systems are absent, the only permanent source of water occurs as seeps, springs, and wells. Other water sources resembling ponds are supplied by occasional precipitation and occur naturally and artificially.

Surface Water

The surface water of this region is generally limited to ephemeral streams that are present only immediately after thunderstorms. The southwestern shrubsteppe region typically receives less than 7 inches of precipitation annually. In addition, there are larger rivers that cross the southwestern shrubsteppe, such as the Pecos and Rio Grande, and the upper reaches of the Gila River, but these are dependent upon the greater rainfall and runoff received in their headwater reaches in the Rockies to traverse this arid region year-round. Although these water resources may be temporally and/or spatially limited, they are quite significant because they provide vital sources of water for wildlife and livestock in a relatively arid environment. Reservoirs along these major rivers also provide surface water habitats and irrigation resources. Areas of this analysis region are used as rangeland, except where converted to irrigation farming. Flooding occurs in winter, spring, and summer; flash flooding is common in summer.

Surface water quality is generally poor, limited by high dissolved solids, sediment, and high temperature. Surface drinking water supplies are limited to supporting wildlife and livestock.

Riparian habitats are usually limited to those areas having perennial surface water. Stream channels are generally low gradient with fine-textured substrates. Typical riparian vegetation consists of saltcedar, certain species of cottonwood and willow, and grass-like species.

Ground Water

The ground-water wells of this analysis region are similar to those of the other regions that occur in the Basin and Range region. The alluvial valley deposits are tapped for their ground-water resources in the southwestern shrubsteppe region and provide most of the water for the area's agricultural practices, industry, and population centers. Significant ground-water resources occur within the thick alluvial sequences that drape from the southern perimeter of the Colorado Plateau and the southern Rocky Mountains.

Chaparral-Mountain Shrub

Surface Water

Surface water resources of the chaparral-mountain shrub region are limited. Because this region generally occurs adjacent to higher elevation areas, it receives more precipitation than lower elevation desert regions, sometimes more than 28 inches annually. The milder temperatures associated with the higher elevations also help to offset the oppressive heat that occurs in the lower elevation regions. Precipitation often occurs in association with thunderstorms, and despite the high runoff and "flash" flooding in ephemeral washes caused by the sloping nature of the chaparral-mountain shrub lands, the dense vegetation of deciduous and evergreen trees and understory brush generally reduce significant slope erosion. Those surface water streams that flow through this region typically have their headwaters established in the nearby mountains. The annual rainfall, the potential evapotranspiration, and the sloping character of this region reduce the establishment of any large surface water bodies, lakes, or ponds.

Ground Water

The chaparral-mountain shrub analysis region occurs between the ground-water recharge areas along the upland ridges and mountains and the lower lying basin and valley discharge areas. Depending upon local geological conditions, springs and seeps may be present and provide localized areas with water year-round. Although ground-water resources are limited, they may often be the only reliable source of water in this region because of the dependence of surface water streams on rain and snowfall conditions in the higher elevations during the winter months. In the chaparral-mountain shrub region, ground-water storage capacity is limited because of thin soils and shallow crystalline bedrock. Although fractured bedrock can provide increased ground-water storage, the best opportunities for ground-water resources exist in those areas that contain at least moderate thicknesses of hillside colluvium or areas underlain by permeable sedimentary or volcanic rock.

Pinyon-Juniper

Surface Water

In the pinyon-juniper analysis region, more than one-half of the annual precipitation occurs in winter;

consequently, there is a general deficiency of moisture throughout much of the year. Only several of the larger streams and their tributaries maintain a yearlong flow, and most of these have their headwaters in higher elevation regions, recharged by snowmelt in the mountains. Much of the water in the streams is stored in reservoirs and is used for irrigation and municipal water supplies. Small natural and artificial lakes at the higher elevations are used for fishing and other recreation.

Runoff from these areas can be extreme, resulting in deeply incised channels and large sediment supplies to downstream areas. Downward channel erosion is limited by bedrock. Surface runoff can be controlled by minimizing the extent of bare soil.

Water quality is generally poor because of high dissolved solids, sediment, and temperature. Use of the water is therefore limited to wildlife and livestock drinking water.

Riparian habitat is limited to areas having permanent water. Vegetation occurs mainly as grass and sedge components.

Ground Water

Ground water is limited and usually occurs only at great depth. Along the western slope of the Rocky Mountains and the Colorado Plateau, the pinyon-juniper region occurs between the higher elevation zones of ground-water recharge and the lower elevation ground-water discharge areas. Some water for irrigation is pumped from deep wells and is generally good quality. The water table in this region is dropping because of pumping in excess of the aquifer recharge. Like the chaparral-mountain shrub region, the ground-water storage capacity in the pinyon-juniper region is limited because of thin soils and shallow crystalline bedrock. Fractured bedrock can provide increased ground-water storage, but the often rugged and irregular topography does not provide much opportunity for ground-water resource development.

Mountain/Plateau Grasslands

Surface Water

In the Columbia Plateau, segments of the Snake and Columbia Rivers drain through the plateau grasslands areas. The more isolated mountain grasslands include areas of Montana, drained by the headwaters of the Missouri River and the upper reaches of the Yellowstone and Bighorn Rivers. This abundance of surface water is contrasted with the Colorado Plateau grasslands, which are more arid.

In this Colorado Plateau grassland region, water is scarce and the low precipitation and intermittent streamflow provide a small amount of water for agriculture. The Little Colorado River, the San Juan River, and the Rio Grande drain through the area but have their headwaters in the higher elevation pinyon-juniper and ponderosa pine areas. Numerous dams and reservoirs have been constructed to more efficiently manage surface water resources in this region. Water from the Navajo Lake in northern New Mexico is to be used for an irrigation project planned for the San Juan River Valley region.

Ground Water

Ground water is plentiful in some areas, although it has been noticeably decreasing over the past several years because of extensive use. Most recharge occurs in the winter during the snowmelt periods. In the Columbia Plateau, the fractured basalt ground-water system is recharged by precipitation and the infiltration of stream water on the plateau surface. In the Colorado Plateau, water moves down the dip of the sedimentary beds, away from the higher elevation recharge areas to discharge along the channels of major streams through seeps and springs, and along the walls of the canyon cut by the streams. The dependence on ground water for irrigation and livestock watering in the mountain/plateau grasslands region requires prudent management of this limited resource.

Plains Grasslands

Surface Water

The northern and eastern portions of this region contain many kettle lakes and prairie potholes that are important to wildlife. The southern sections have many playa lakes; most of these are intermittent, although some are moist year-round. The relatively few perennial streams are typically broad, sluggish, and silt-laden. Many ponds and small reservoirs have been constructed on intermittent streams, and large reservoirs have been constructed on larger rivers.

Water quality is generally good, capable of supplying any use. Some salinity problems can occur because of agricultural irrigation practices or where salts are allowed to accumulate near the soil's surface.

Stream channels are generally of low gradient in fine to moderately fine substrates. Woody vegetation, particularly cottonwood and willow play an important role in providing stability and cover. Slow moving streams, ponds, and bogs provide ideal con-

ditions for sedge, tule, and willow development. Substrates can provide ideal fisheries habitat, except where excessive erosion may provide sediment that fills pools and covers gravel areas.

Ground Water

The High Plains region is underlain by alluvial materials derived from the Rocky Mountains, referred to as the Ogallala Formation, which forms one of the most productive and most intensively developed aquifers in the United States. Natural discharge from the aquifer occurs to streams and seeps along the eastern boundary of the plains.

The widespread occurrence of permeable layers of sand and gravel, which permit the construction of large-yield wells almost any place in the region, has led to the development of an extensive agricultural economy largely dependent on irrigation. Most of this water is derived from ground-water storage, resulting in a long-term continuing decline in ground-water levels in parts of the region of as much as 3 feet per year. In areas where intense irrigation has long been practiced, the depletion of ground-water storage is severe. The lowering of the water table has resulted in a 10- to 50-percent reduction in the saturated thickness of the High Plains aquifer in an area of 12,000 square miles (Heath 1984). Although the decline in the water table and reduction in the saturated thickness are cause for concern, from a regional standpoint the depletion does not represent a large part of the storage that is available for use. Future developments in High Plains ground-water resources should be oriented toward maintaining aquifer conditions to ensure water supplies for later use.

Coniferous/Deciduous Forest

Surface Water

Water is generally abundant in the central and northern sections of this region. Many of the larger surface streams that flow through these regions originate in the mountains. Natural lakes are common, and numerous large and deep reservoirs have been constructed on major rivers to provide water for irrigation, power, and domestic and municipal uses. Most natural lakes and ponds are relatively shallow and are rich in organic matter. Reservoirs are typically much deeper and colder, and are relatively nutrient poor.

Water quality in most cases is very good, suitable for any use. Typical total dissolved solids are below 100 mg/L and are regulated by the solubility of the geologic formations. Temperature and dissolved oxygen are suitable for cold water fisheries where topographic and vegetative shading provide solar radiation control.

Water use in the coniferous forest regions is limited to drinking water supplies for livestock, wildlife, and people. Occasionally, water is used during mining and construction.

Streams can be described in terms of erosional and depositional segments. Depositional segments generally have high gradients (greater than 0.01 feet per foot) with bedrock or course substrate, or depositional segment, with lower gradients and finer substrate. Erosional segments are often confined by the valley walls, and as a result, streamside vegetation is limited to conifers and whatever wetland vegetation can exist in the limited soil. Large organic debris may be important in providing aquatic habitat diversity. Depositional segments often provide highly productive wetland vegetation.

Ground Water

Ground water, relatively abundant in many valleys, is used for irrigation and livestock watering. In ridges and in intermountain basins, ground water is usually scarce. Water quality in the region is generally good, although salinity is a problem in the lower reaches of many major streams. Southern sections of this region and lower elevations have more moderate supplies of water. Ground-water supplies are limited.

Fish and Wildlife

No single Federal or State agency manages more fish and wildlife habitats than the Bureau of Land Management. The 158 million acres in this 13 State EIS area sustain an abundance and diversity of fish and wildlife resources. As population pressures restrict American wildlife habitats, the varied habitats on public land are becoming increasingly important in maintaining a national fish and wildlife heritage. The public lands provide a permanent or seasonal home for more than 3,000 species of mammals, birds, reptiles, fish, and amphibians.

Public lands provide significant portions of the habitat of many of the species that have made tremendous recoveries in their numbers since the turn of the century. One of the most dramatic increases in numbers has occurred with the pronghorn antelope. Public lands make up about 45 percent of the habitat of the pronghorn antelope in the West (BLM 1988). Approximately 288,000 currently occur on public lands in the EIS area (BLM 1988); in 1922-24 the entire U.S. population of pronghorns was estimated at only 13,000 head (Wildlife Management Institute 1980). BLM also manages 80 percent of the remaining habitat for the desert bighorn sheep (BLM

n.d.). Their populations have been expanded dramatically in recent years through transplants and habitat and water developments, increasing in the mid-1980s to around 5,000 in the EIS area (BLM 1988). The public lands also provide habitat for many of the 78 endangered and threatened wildlife species that occur in these 13 States (50 CFR 17.11) (Appendix H). Wildlife habitat management on the public lands will continue to be significant to the recovery of many of these species.

With the tremendous variation of terrestrial habitats on public lands, from alpine mountain crests in Montana to near sea level, hot, arid deserts in southwestern Arizona, there is a comparable variety of wildlife species. Wildlife species range from mountain goats and grizzly bears to Gila monsters and javelina. For this document, however, the habitats found at the extreme limits of climatic situations do not lend themselves to the types of vegetation treatments analyzed in this EIS because of the tremendous limitations in growing conditions. Therefore, there will be few impacts to their wildlife communities, and it is unnecessary to discuss them in great detail. Likewise, there are small localized wildlife species (for example, most invertebrates) that can only be addressed in general terms because the impacts would be site-specific and would require careful consideration in the site-specific activity plans. The primary discussion in this affected environment chapter will be limited to those species that would most likely be affected on a general scale.

Perhaps the consistently most significant wildlife habitats on public lands are the riparian habitats. As a general practice the riparian areas will be avoided by the treatments proposed in this EIS; however, a few manual, herbicide, and burning treatments will be used in riparian areas primarily for the purpose of controlling exotic, undesirable vegetation.

Undisturbed riparian ecosystems normally provide abundant food, cover, and water, and often contain some special ecological features or combination of features that are not often found in upland areas. Consequently, riparian ecosystems are extremely productive, and have diverse habitat values for fish and wildlife. The importance of riparian ecosystems can be attributed to specific biological and physical features, including:

(1) Predominance of woody plant communities;

(2) Presence of surface water and abundant soil moisture;

(3) Close proximity of diverse structural features (live and dead vegetation, water bodies, non-vegetated substrates), resulting in extensive edge and structurally heterogeneous wildlife habitats;

(4) Distribution in long corridors that provide protective pathways for migrations and movements between habitats. (Brinson et al. 1982)

The wildlife group most directly affected by the quality of riparian habitat are the fisheries communities. The quality of fisheries habitat has a direct correlation to the health of the riparian community (AFS 1980). Riparian areas are also extremely significant to bird populations. Eighty-two percent of breeding birds in northern Colorado occur in riparian areas, and 51 percent of all bird species in the Southwestern States are completely dependent on riparian areas (Knopf et al. 1988). Riparian areas also attract a disproportionate number of migrating bird species. In comparison to surrounding uplands, riparian areas may attract up to 10 times the variety of bird species in the spring, and 14 times the numbers in the fall (Knopf et al. 1988). Other vertebrate species are also highly dependent on riparian areas (Knopf et al. 1988). Xeroriparian areas are also significant wildlife habitats and should receive special consideration in treatment planning. The significance of xeroriparian areas as wildlife habitats have been demonstrated for the full realm of desert wildlife species, from mule deer (Krausman et al. 1985) through the avian species (Johnson and Haight 1985).

The aquatic habitats are as diverse as the terrestrial habitats, ranging from portions of the Columbia and Snake River systems to isolated springs in the hot desert regions. Both anadromous and resident fish species occur, including introduced species as well as native species. Many aquatic stream environments do not easily lend themselves to divisions by analysis regions because they flow through several vegetation zones, with the headwaters in the higher elevations in coniferous or alpine regions and flowing down into grassland or desert regions, often within a few miles. Streams often have their headwaters on non-BLM-administered lands.

Fisheries will be divided into three categories for ease of discussion. Anadromous fisheries are cold water habitats used by fish species that migrate from the ocean up a fresh water stream to spawn, with the young returning to the ocean to mature. Typical anadromous species include the Pacific and coho salmon and the steelhead trout. Cold water resident fisheries are cold water habitats; streams are characterized by low water temperature, definite channel gradient, sand, gravel or rock substrate, strong currents, high oxygen content, low nutrient values, and lack of rooted aquatic vegetation (Smith 1966). The classification is less definite for lakes: generally the water temperature remains cold year-round (below 60° F), nutrient values are low, and aquatic plants are not abundant (USDI 1986x). Typical fish species in cold water habitats include the native cutthroat, Apache and Gila trout, native suckers and minnows,

and the widely introduced rainbow, brook, and brown trout. Warm water fisheries are characterized by higher water temperatures, gentle channel gradients, soft bottom materials, slow currents, lower oxygen content, high nutrient values, and substantial rooted aquatic vegetation. Lakes often have similar characteristics, less channel features, and have at least one warm season exceeding the water temperature limits of cold water fish species (Smith 1966.) Typical warm water species include the bluegill, largemouth bass, crappie, catfish, squawfish, pupfish, and the exotic Asian carp (Cooperrider et al. 1986). More detail on the fisheries resources in the EIS area will follow the discussion of the analysis regions.

The invertebrate species on public lands are poorly studied, but are known to be numerous and very diverse due to the incredible variation of habitats managed by the BLM. Because of this diversity, the state of knowledge, and the scope of this document, it is not possible to cover the subject in detail. The invertebrate segment of the wildlife community will not receive any further discussion within the analysis region discussions that follow.

Following are the discussions of the general wildlife species and habitat relationships found on public lands within the analysis regions occurring in the 13-State EIS area.

Canada Thistle

Sagebrush

Because of its expanse, the sagebrush region is a very significant wildlife habitat, though it contains less species diversity than most other vegetation regions. Sagebrush is typically associated with the cold desert where some snow and cold weather occurs during the winters, which causes wildlife to use habitat areas in seasonal shifts. Also, sagebrush is commonly an elevational biotic zone with pinyon-juniper or conifer forest above and saltbush, greasewood, riparian, grassland, or other sagebrush flats below. As a result, sagebrush can be used as a singular habitat type or in conjunction with other vegetation habitat types.

As a singular habitat type, sagebrush is often monotypic over large areas. Few species find these large expanses as high-quality habitat. The best sagebrush habitat includes a mix of multi-age sagebrush with associated perennial bunch grasses and forbs, and interspersed with open wet meadows or riparian areas. Typical wildlife of open sagebrush include the sage grouse, sage thrasher, sage sparrow, sagebrush lizard (all named for the type of vegetation), black-tailed jackrabbit, pygmy cottontail, Ord's kangaroo rat, Great Basin kangaroo rat, deer mouse, Columbia ground squirrel, sagebrush vole, white-tailed prairie dog, badger, coyote, black-billed magpie, gray flycatcher, canyon wren, horned lark, burrowing owl, red-tailed hawk, ferruginous hawk, and several other raptors. Reptiles of the sagebrush region include the common garter snake, western rattlesnake, western skink, and sagebrush lizard. Pronghorn antelope can be very common in sagebrush type when the sagebrush is less than 24 inches tall, a variety of forbs and other forage are present, the stand is open (less than 50 percent cover), and water and other habitat components are available (Cooperrider et al. 1986). When sagebrush occurs in conjunction with broken terrain—especially rimrock—mule deer, golden eagles, prairie falcons, and in some areas, bighorn sheep or chukar partridge may commonly occur. In areas of limited rainfall and forage production, the thermal cover provided by sagebrush may be critical to deer and other wildlife survival (W. A. Molini, pers. comm. 1990).

As an elevational ecotone, the sagebrush vegetation zone is an extremely significant wildlife habitat. Along the slopes of many western mountain ranges, the sagebrush vegetation type, often in conjunction with scattered juniper and pinyon, commonly occurs below deep snow areas, making them suitable as wildlife (especially big game) winter ranges. Although most sagebrush and juniper species are

low-quality forage, they are usually associated with high-quality browse species, such as bitterbrush, mountain mahogany, and cliffrose. Most critical western winter ranges have sagebrush as a significant portion of their vegetation component. In addition to the mule deer and elk, the large predators and scavengers also congregate on the winter ranges. Mountain lion, bobcat, coyote, bald and golden eagles, and ravens are winter residents of the sagebrush region.

Riparian areas or wet meadows are critical to the rearing of sage grouse broods (Call 1974). Riparian areas with large deciduous trees, such as cottonwoods, are the most significant for most nongame birds and raptors. Their variety and densities increase significantly in these multilayered riparian systems (Cooperidder et al. 1986). Of the 148 species of breeding birds in the Great Basin, only 17 (11 percent) do not use riparian areas (Ohmart and Anderson 1982). Riparian areas are also significant to big game. Pronghorn antelope use them extensively in summer (Cooperidder et al. 1986). Mule deer and elk also use riparian areas extensively for food, cover, and travel and migration corridors (Thomas et al. 1979). Riparian vegetation is also significant to the maintenance and quality of cold water stream fisheries. Numerous studies have documented the relationship of good condition riparian habitat to high-quality trout populations (Platts 1984).

Desert Shrub

The desert shrub analysis region consists of two major, but dissimilar, vegetation ecosystems. The saltbush-greasewood association is a cold desert community, very often a lower elevation or lower available moisture condition within the sagebrush analysis region. The second ecosystem is a hot desert association composed of the Mojave and Sonoran Deserts and is typified by creosotebush and creosotebush/bur sage vegetation communities.

The saltbush-greasewood association extends from southeast Oregon and western Nevada to the Bighorn Basin in Wyoming and the San Luis Valley in Colorado. Neither of these two vegetation communities are high-quality wildlife habitats, but in conjunction with adjacent vegetation communities, can provide valuable habitat diversity. Typical wildlife species using these habitats include desert kangaroo rats, little pocket mice, jackrabbits, horned larks, vesper sparrows, loggerhead shrikes, western whiptail and side-blotched lizards, and rattlesnakes. The pronghorn antelope may make extensive use of this type in conjunction with other vegetation types (Shelford 1963).

These vegetation communities are generally associated with saline basins and valley floors commonly within closed water basins. Permanent water is extremely scarce and natural fisheries resources are almost nonexistent. However, some very unique fisheries occur in permanent springs and marshes in the bottom of several isolated valleys.

The hot desert region includes southern Nevada, extreme southwestern Utah, and extreme western and south-central Arizona. The hot desert associations are much more diverse than either the saltbush-greasewood association or the sagebrush cold desert regions and contain some unique wildlife species. Hot deserts are typified by having evaporation rates far exceeding the annual rainfall; therefore, the native plants and animals are often extremely well adapted to surviving arid conditions. Several animals are present throughout this area. These include the bighorn sheep, mule deer, kit fox, spotted skunk, Merriam's kangaroo rat, rock squirrel, Harris' antelope squirrel, southern grasshopper mouse, Harris' hawk, zone-tailed hawk, Gambel's quail, white-winged dove, common ground dove, elf owl, Bendire's thrasher, phainopepla, Lucy's warbler, Abert's towhee, desert tortoise, sidewinders and other rattlesnakes, and several lizards (Shelford 1963).

Like the uplands, the riparian habitats in the desert shrub region are extremely varied. Riparian areas are scarce, except along the Colorado River system drainages in Arizona, Utah, portions of Colorado, and Nevada; neither the saltbush desert nor the hot desert portions of the region have any significant quantity. Most of this riverine habitat has been severely depleted with the impounding and channelization of the rivers and has been heavily invaded by the exotic saltcedar. The river impoundment flooded pre-existing riparian areas, clearing the riparian bottomland and reducing the natural reproduction of native species. This allowed for significant invasions of exotic species, especially saltcedar (Ohmart and Anderson 1982). Consequently, the total area of riparian habitat is greatly reduced from predevelopment times, making the remaining riparian habitats very significant.

At the higher elevations and better quality areas of the saltbush desert, the riparian discussion in the sagebrush section will generally apply. But on the whole, the saltbush desert is very poorly watered and riparian areas are almost nonexistent. The hot desert portions of the analysis region are the Mojave and Sonoran Deserts; these areas are just as poorly watered and riparian areas are also rare. The most significant riparian habitats are related to the major river systems, or an occasional isolated side canyon, where the cottonwood-willow communities were historically dominant. This community has been reduced by nearly 50 percent on the lower Colorado River, and less than 20 percent of that remaining is good-quality habitat (Ohmart and Anderson 1982).

Southwestern Shrubsteppe

The southwestern shrubsteppe is historically a hot, arid, desert grassland. Past uses resulted in significant invasion by brushy vegetative species. These areas of brushlands fragmented and isolated the remaining areas of desert grassland. This resulted in reducing suitable habitat and numbers of the native grassland wildlife species, reducing their population viability. Many species have been lost (aplomado falcon, wolf, grizzly bear, black-footed ferret) and replaced by brushland species. Others have been reduced in numbers. The reduction in pronghorn antelope and Coues' whitetail deer and the increase in mule deer and javelina are examples of the species replacement process resulting from vegetation changes.

Wildlife species typical of the southwestern shrubsteppe include the bannertail kangaroo rat, black-tailed jackrabbit, badger, white-throated wood rat, pronghorn antelope, black-tailed prairie dog, Coues' white-tailed deer (in the western portion at higher elevations), scaled quail, Gambel's quail, lesser nighthawk, vermilion flycatcher, Chihuahuan raven, verdin, cactus wren, pyrrhuloxia, McCown's longspur, green toad, southern prairie lizard, round-tailed horned lizard, desert grassland whiptail, western hooknosed snake, Mexican black-headed snake, and massasauga. Desert bighorn sheep have been re-introduced into several historic habitats in this region.

Yellow Starthistle

Riparian communities in the southwestern shrubsteppe are similar to and are as significant as those in the hot deserts of the desert shrub region. Extensive channelization, impoundment, and phreatophyte clearing have occurred along the Rio Grande and Pecos Rivers (Ohmart and Anderson 1982). In their comparative study, Ohmart and Anderson found the riparian communities in the Chihuahuan desert to have a higher total number of bird species (322) and riparian-related species (273) than any of the other western deserts. The newly designated San Pedro (River) Riparian National Conservation Area is located in this region. It is one of the most significant wildlife habitats in the Southwest.

Chaparral-Mountain Shrub

This is the most widely scattered community and probably the least extensive. Included in this region are the mountain mahogany-Gambel's scrub oak communities of Nevada, Utah, and Colorado, and the Arizona interior chaparral vegetation communities of central and southeast Arizona and southwest New Mexico. Both of these communities can be excellent wildlife habitats, but the Arizona chaparral is especially prone to becoming too dense and limiting its availability to all but the smaller species. The mountain mahogany-scrub oak community is extremely valuable wildlife winter range, though its elevational range generally has sufficient snow depth to limit its usability to only the larger species, such as elk and moose, during deep snow periods. Mule deer may use this type year long or during all but the worst of the winter. Because of this use by big game species, this region is also valuable to large predators and carrion feeders.

The chaparral-mountain shrub analysis region has much diversity. Large mammals, including the mule deer, coyote, mountain lion, bobcat, and gray fox, are widespread in this analysis region. White-tailed deer and collared peccary appear in the southern parts. Black-tailed jackrabbit, striped skunk, and spotted skunk also occur. Ringtail cat is a predator adapted to thick cover in this region where it hunts for several different smaller mammals, including white-footed mice and brush mice. The wood rat is one of the most characteristic animals of this analysis region. Other small mammals include species of ground squirrels and mice.

Birds are numerous throughout the year in the brush types of the region; more than 50 resident species were identified in the scrub oak type in Utah.

Distinctive birds in the chaparral-mountain shrub analysis region include the wrentit and rufous-sided towhee. Other birds include the mountain quail, black-throated gray warbler, scrub jay, Bewick's wren, plain titmouse, acorn woodpecker, and saw-whet owl.

Reptiles that feed on insects, bird eggs, nestlings, and small mammals include the pinegopher snake; wandering garter snake; and night snake, which can be quite common, especially in the southern part of the analysis region.

The chaparral and mountain shrub regions are generally montane communities. Riparian areas are characterized by small mountain streams that flow through several other regions in addition to the chaparral and mountain shrub. As in all habitats, the riparian areas are a focus for wildlife because of the added diversity and high productivity of riparian communities. Many of these streams are habitat or potential habitat for native western trout and other native fishes and aquatic organisms.

Pinyon-Juniper

Past management practices have resulted in significant changes in the density of pinyon and juniper tree stands. The tree stand densities have increased, often to the detriment of more valuable vegetation species, lowering the quality of the wildlife habitat. This also has resulted in reducing the amount of high-quality edge vegetation habitat and replacing it with more monotypic vegetation. Current management is often aimed at reducing tree densities to improve associated forage species volumes and to recreate the lost edge habitat and habitat diversity. Dense stands of juniper may offer high-quality nesting and thermal cover, but little else. Pinyon stands may have similar values, but in addition produce pinyon nuts, which are an excellent wildlife food. As in the sagebrush region, this vegetation community provides a better wildlife habitat when it occurs in conjunction with other communities than when it occurs as an expansive habitat. Also like sagebrush, the size and shape of the openings created by vegetation treatment are critical to the future values of this vegetation type as quality wildlife habitat.

Not many wildlife species are solely dependent on the pinyon-juniper vegetation type. Some of the typical wildlife species are the mule deer, elk, desert kangaroo rat, pinyon mouse, bobcat, mountain lion, nesting red-tailed hawk, Swainson's and ferruginous hawks, golden eagles, wintering bald eagles, wild turkey, ash-throated flycatcher, western wood peewee, scrub jay, pinyon jay, Clark's nutcracker, and plain titmice. The reptiles of this analysis region are similar to those in adjacent desert and forest communities and include the striped whip snake, California king snake, horned lizard, sagebrush lizard, collared lizard, Great Basin rattlesnake, and western hooknosed snake. The evergreen oak-alligator juniper vegetation community in southeastern Arizona has several unique wildlife species associated with it, including the coati, the Ringtail cat, the black bear, Coues' white-tailed deer, wild turkey, Montezuma quail, band-tailed pigeon, whiskered owl, white-eared hummingbird, Strickland's woodpecker, gray-breasted jay, bridled titmouse, black-chinned sparrow, giant spotted whiptail, Mexican garter snake, and twin-spotted rattlesnake.

The riparian areas and upland relationships in the pinyon-juniper analysis region are very similar to that of the chaparral-mountain shrub region. The highest number of wintering bird species and second highest wintering bird densities recorded occurred in a riparian area adjacent to a juniper-oak woodland in an Arizona canyon (Brinson et al. 1981).

Mountain/Plateau Grasslands

This region contains many different wildlife habitats, from high mountain meadows to southern plateau grasslands. Also included in this variety are the edges of these grassland communities with numerous forest and brushland types.

On the Columbia Plateau, shrubs were originally of little importance. Cool-season bunchgrasses covered broad areas. Today, overgrazing has greatly changed the dominance of shrubs, such as sagebrush, saltbush, rabbitbrush, and bitterbrush (Shelford 1963). Pronghorn antelope are resident and mule deer and elk are winter visitors. Where there is a common boundary with the sagebrush analysis region, common animals include the black-tailed jackrabbit, pygmy cottontail, and various mice. At low to medium elevations, various subspecies of ground squirrels are present, as well as badgers. The pocket gopher is well distributed throughout the region. Predators include the bobcat, mountain lion, and coyote. Common birds include the scrub, pinyon, and Stellar's jays; Clark's nutcrackers; rock and canyon wrens; and dark-eyed juncos. Marsh hawks, American kestrels, and golden eagles are common raptors. Reptiles include the lesser earless and collared lizards, the western terrestrial garter snake, and the pine gopher snake.

On the Colorado Plateau, warm season bunchgrasses are found with sagebrush and blackbrush. Many of the animal species found here are also found in the other grasslands or desert shrub regions. Species include the ringtail, least chipmunk, desert wood rat, Utah white-tailed antelope squirrel, and black-tailed jackrabbit. Desert reptiles include sagebrush, collared, tree, and side-blotched lizards; pine gopher snake; and striped whip snake. Animals unique to the area include the Utah white-tailed prairie dog, plateau whiptail, Painted Desert glossy snake, and Mesa Verde night snake.

The riparian communities of this analysis region are diverse, ranging from high elevation alder and willow and blue spruce communities to mixed deciduous and cottonwood gallery forests at lower elevations. Because of the extreme diversity that riparian vegetation adds to the open, low-growing vegetation of the surrounding grassland, the wildlife habitat values are very high. In addition to the normal values of riparian habitats (such as increased habitat edge, a complex of foliage height diversity, increased insect communities, higher humidity, available water, and a totally different forage species availability from the surrounding uplands), in this region riparian vegetation also provides the thermal cover not available in the grasslands. The contrast in values between the riparian areas and the adjacent uplands is probably most dramatic in the grassland analysis regions than any of the others, making the riparian zone especially valuable to wildlife.

Plains Grasslands

The plains grasslands, both mixed and short, support a unique group of animals. Many grassland animals are burrowers; others are swift runners. Most of these species have keen eyesight and are quite gregarious, forming either large herds or enormous colonies (Shelford 1963).

Huge herds of American bison once migrated with the seasons across the central plains. Now, the pronghorn antelope is probably the most common large mammal, but mule deer and white-tailed deer are often abundant where brush is available, such as along stream courses. Burrowing rodents include ground squirrels, prairie dogs, pocket gophers, and pocket mice. Burrowing predators include the badger, kit fox, spotted skunk, and the endangered black-footed ferret. The white-tailed jackrabbit occupies the northern part of the ecosystem, and the black-tailed jackrabbit, the area south of Nebraska. The desert cottontail is widespread.

Birds in the plains grasslands include horned lark, killdeer, western meadowlark, sharp-tailed grouse, and burrowing owl. The prairie pothole region of the northern plains is nationally significant waterfowl habitat. Numerous species of ducks, geese, and shorebirds use these important wetland habitats, including federally listed threatened and endangered species, such as bald eagles, American peregrine falcons, whooping cranes, least terns, and piping plovers. Construction of stock ponds has created additional important duck habitat in the northern Great Plains.

Reptiles include the western hognose snake, great plains skink, and plains garter snake. Amphibians of the region include the plains spadefoot, great plains toad, and western box turtle.

In this analysis region most of the major waterways, and their associated riparian areas, have a west to east orientation. The typical vegetation of the plains riparian areas are the cottonwood and the cottonwood-willow communities in the west, and the mixed broadleaf communities in the east. These riparian corridors are travel routes for wildlife from mid-continent moving westward and for the mountain species moving east. The white-tailed deer, raccoon, opossum, and numerous birds extend into the west along the riparian areas. Historically, the grizzly bear and bighorn sheep extended eastward onto the plains along the riparian corridors and their associated breaks and canyons. The elk and mule deer are still in these areas.

The riparian areas are extremely significant wildlife habitats in the plains grasslands. They support unique wildlife species, such as the beaver, and are of utmost importance to migrating birds. Many migrating bird species move from riparian area to riparian area. The prairie potholes and manmade reservoirs are also significant on these migration routes. These locations on the northern plains are also very important for waterfowl production. With the development of the upland plains for agricultural purposes, the plains riparian areas are often the most significant remaining natural cover habitats for maintaining many of the native and introduced wildlife species of the prairies.

Coniferous/Deciduous Forest

The type of conifer forest found in a locality depends on the climate regime, rainfall, and soil development of the area. Important forest types include the ponderosa pine, Douglas-fir, and fir-spruce forests. Mule deer range throughout these forests, preferring rough terrain for cover and shrubs for food. Elk also occur widely, grazing in high mountain meadows in the summer and shrublands in the winter. The mountain lion is the chief predator on deer and elk. The black bear is an agile climber frequently found throughout the Rockies. Other animals found in western forests include the northern flying squirrel, a common, but rarely seen species; Abert's squirrel, common in the southern Rockies and closely associated with the Ponderosa pine; the red squirrel, which is found throughout the Rockies and prefers spruce-fir forests; and the widespread golden mantled ground squirrel. The porcupine and the beaver are the largest forest rodents.

Resident birds in this region include the pygmy nuthatch, Stellar's jay, sharp-shinned hawk, red-breasted nuthatch, mountain chickadee, Cassin's finch, northern flicker, dark-eyed junco, Swainson's thrush, western goshawk, and red-tailed hawk. Birds that are common during the summer include the western bluebird, yellow-rumped warbler, William-

son's sapsucker, western flycatcher, and western tanager. Three grouse species may also occur. The spruce grouse inhabits the higher elevation spruce and fir forests, the blue grouse uses mid and lower elevation forests, and the ruffed grouse is most common in riparian areas.

The region's common reptiles include the wandering garter snake, pine gopher snake, and western rattlesnakes. The most common amphibians include the Rocky Mountain toad and the common leopard frog of the Rocky Mountain States (Dickerson 1969).

The deciduous forest portion of the analysis region is primarily aspen forest and parkland. Aspen, being one of the most widespread plants in the world, is a very important wildlife habitat. Aspen groves are commonly associated with coniferous forest and mountain meadows and grasslands. They typically provide extensive edge and habitat diversity. Aspen stands also tend to have much more ground cover than the coniferous forests. Aspen leaves and new growth shoots are also very palatable to big game animals. The combination of these factors makes the aspen communities one of the most important habitats in the conifer forest analysis region.

Riparian areas in coniferous and deciduous forests frequently provide more edges within a small area than expected. In addition, there are many vegetative strata exposed in a stairstep fashion providing diverse nesting and feeding opportunities for wildlife, especially birds and bats. Bird species are commonly associated with specific, distinct layers of vegetation, so abundantly supplied by healthy riparian communities. Bird species also select between coniferous and deciduous vegetative volumes in distinct strata, providing added diversity (Thomas 1979). Other wildlife also are attracted to these riparian areas. In the northern and central Rocky Mountains, moose most commonly occur in riparian areas within the coniferous forest analysis region. In the Blue Mountains of Oregon, elk spent 40 percent of their time in riparian zones that only made up 7 percent of their habitat use area (Thomas 1979). Riparian areas are also commonly used as migration corridors during seasonal elevational migrations.

Fisheries Resources

Fisheries resources within the EIS area have been greatly affected by ecosystems outside the area. East of the Rocky Mountains, the Mississippi River provided a giant dispersal corridor for fishes across half the continent. Differing conditions in this large basin led to localized changes in fish communities, leaving a mixture of widespread and species of limited range adapted to localized conditions. To the west, other river systems flowed into the Pacific Ocean. In past geologic times these waters were connected to the Mississippi River system and fish crossed the divide. The Pacific Ocean also provided an alternative feeding ground and migratory route, and a high percentage of coastal species developed anadromous habits. Other river systems, like the Rio Grande and Colorado, became isolated. In these systems where stream habitats flowed from alpine cirques to arid, hot deserts, a fauna low in species but diverse in adaptations developed. Between the major river system are basins once connected to these river systems or to the oceans. As the basins dried, the fish species evolved to become adapted to smaller and smaller habitats, becoming increasingly isolated from other originally related species. A high degree of endemism resulted (BLM 1990).

Because of these origins a description of the fisheries resources of the EIS area, like the riparian habitats, does not logically coincide with the geographic analysis region format. The fisheries resources will be divided into three regions: Northwest, Mountain States, and Desert Southwest as organized in the Fisheries Habitat Management on Public Lands, A Strategy for the Future (BLM 1989) report. The Northwest region includes the states of Washington, eastern Oregon, and Idaho. This region includes an enormous anadromous fisheries resource. The anadromous fish habitats are the large river systems with direct ocean access. All streams in the EIS area are part of the Columbia River system including the Deschutes and John Day Rivers in Oregon, and portions of the Salmon, Snake, Little Salmon, and Clearwater Rivers in Idaho. Important anadromous fish species in the EIS portion of these three states are chinook and sockeye salmon, steelhead trout, Pacific and river lampreys, and historically the white sturgeon. Although remaining a significant economic resource, the salmonid anadromous fish population has declined by one-third since the 1870's.

Through recent efforts the population trends have turned upward, though will probably never reach historic levels again due to the significant loss of habitat from development of hydroelectric dams and other man-caused habitat degradation from agriculture, logging, mining, road building, channelization and other land uses. In the past 20 years the awareness of anadromous fisheries habitat problems have increased and progress is being made in improving habitats and correcting past management practices leading to the original degradation (BLM 1989). Resident fisheries in the Northwest were historically fishes of cold-water streams and mountain valley lakes. The most common species were the westslope, Yellowstone, and fine-spotted cutthroat trout, redbanded rainbow trout (Behnke 1979), and Dolly Varden trout, the mountain whitefish and suckers, western squawfish, chiselmouth, speckled dace and other minnows, and several species of sculpins (Eddy 1957). Man has introduced the coastal rainbow, eastern brook, golden trout, and German

brown trout to these stream environments, and most lakes and reservoirs. Man-made features have also changed the fisheries habitats. Numerous dams on the main and tributary rivers have resulted in many reservoirs and small impoundments that have also been stocked with fish in addition to the natural populations. Many of these dams have also interfered with the natural stream migrations and eliminated streams as anadromous fisheries, at least for some species.

The white sturgeon has been trapped by many dams that still allow the salmon to migrate. Lake trout and kokanee salmon have also been added to many reservoirs and lakes. Also introduced are the warm water species like catfish and bullheads, small and largemouth bass, walleye, northern pike, black and white crappie, yellow perch, and numerous sunfish, as well as several minnows introduced as forage fish for the game species, and of course the carp. These introduced fish compete with the native species in many streams and lakes. Most native trout populations have been severely limited in major streams.

The Mountain region is composed of the states of Colorado, Montana, Wyoming, and parts of Nevada, Idaho, Utah, and New Mexico. Habitats are very similar to the Northwest region, being primarily cold water streams and mountain lakes, but lacking the anadromous salmon fishery. Native resident fish species are also very similar except for some different subspecies of the cutthroat trout (westslope, Yellowstone, Bonneville, Colorado River, greenback, Rio Grande, and Yellowfin), Arctic grayling, and native rainbow trout. The species associated with the non-headwater portions of the major river systems of the Missouri, Platte, Arkansas, and Rio Grande Rivers are much different fish, like the paddlefish, burbot, carpsucker, sicklefin chub, stonecat, sauger, and the Arkansas River darter (Eddy 1957). The situation of introduced fisheries is virtually the same as the Northwest region.

The Desert Southwest region includes the states of Arizona, Nevada, New Mexico, and Utah. The Colorado River system is the dominant drainage system for this region, with the Rio Grande and Pecos Rivers also being important in New Mexico. As discussed in the section on riparian vegetation, the historic stream conditions in the Desert Southwest region have been impacted. Free flowing habitats are very rare and even these have been heavily impacted by exotic fish species. The large rivers have become a series of impoundments and most of the smaller streams are either dry or have severely limited flows, generally in deeply incised channels. Also many fish were in isolated water sources, relicts of past geologic periods when they were contiguous with other water bodies.

The Southwestern fishes have been characterized as a depauperate fauna of relicts, monotypic genera, and much regional endemism (Miller 1961). Several species of fish are extinct (Parras roundnose minnow, Pahranagat spinedace, Spring Valley sucker, Leon Springs pupfish, Monkey Springs pupfish, Phantom shiner, Rio Grande bluntnose shiner, Grass Valley speckled dace, Las Vegas dace, Raycraft Ranch poolfish, Pahrump Ranch poolfish, Ash Meadows poolfish, Utah Lake sculpin, and Independence Valley tui chub), and many others are threatened or endangered.

Native resident species which are currently at low population levels are: Apache trout; Lahontan, Colorado River, Bonneville, Gila, and Rio Grande cutthroat trout; desert dace, 12 subspecies of Nevadan tui chubs, humpback chub, Sonoran chub, bonytail chub, Gila chub, Chihuahua chub, Yaqui chub, Pahranagat roundtail chub, Virgin River roundtail chub, Moapa roundtail chub, White River spinedace, Virgin River spinedace, Little Colorado spinedace, Big Springs spinedace, Moapa dace, spikedace, Yaqui beautiful shiner, Pecos bluntnose shiner, woundfin, Colorado squawfish, relict dace, Big Smokey speckled dace, Independence Valley speckled dace, Moapa speckled dace, Ash Meadows speckled dace, Clover Valley speckled dace, Preston speckled dace, Amargosa speckled dace, Meadow Valley speckled dace, Pahranagat speckled dace, loach minnow, White River sucker, Meadow Valley desert sucker, Zuni blue sucker, Wall Canyon sucker, cui-ui, June-sucker, razorback sucker, Yaqui catfish, Preston White River springfish, White River springfish, Moapa White River springfish, Moorman White River springfish, Railroad Valley springfish, Devil's Hole pupfish, Ash Meadows Amargosa pupfish, Warm Springs Amargosa pupfish, Pecos River pupfish, White Sands pupfish, Pahrump poolfish, Pecos gambusia, and Gila topminnow (Williams, et al. 1985).

The introduced fish species include most of those of the other two regions plus several more warm water species, including: grass carp; fathead minnow; red shiner; bigmouth and smallmouth buffalo; flathead, blue, and channel catfish; mosquitofish; spotted, white, and striped bass; tilapia; sailfin mollies and several other aquarium species escapees.

The general view of the fisheries resources in the Northwest and Mountain regions, except for the large river reservoirs, is one of apparently intact systems, while in the Desert Southwest, the view is of totally artificial fisheries.

Cultural Resources

The BLM defines cultural resources to include both properties and traditional lifeway values (BLM 1988e). Properties consist of anything that shows evidence of having been made, used, or altered by humans. A traditional lifeway value is the quality of being useful in or important to the maintenance of

a specified social or cultural group's traditional systems of religious belief, cultural practices, identity, or social interaction. In some cases, a traditional lifeway value may be associated with a property while in others in may be independent of a property or definable location.

Prehistoric cultural properties are those left by the groups that have lived in the Western United States since the first human migration to the western hemisphere at least 12,000 years ago. The historic period began with the European migration to the New World in 1492, and the associated end of traditional cultures caused by the spread of Euro/American culture across the United States.

In the western United States, the spread of Euro/American culture did not begin until 1539 in the Southwest and significant destruction of traditional cultures did not begin until the 1600 and 1700's. In other areas, such as the Pacific Northwest and the Great Basin, the historic era did not begin until the 1800's and traditional cultures were not significantly effected before the middle to late 1800's.

Traditional lifeway values may be associated with properties from either the prehistoric or historic eras. When the value is associated with the prehistoric era it is also associated with Native American traditional values, traditional land uses, and/or religious beliefs and may be subject to the requirements of the American Indian Religious Freedom Act (42 U.S.C. 1996). Values associated with the historic era are not necessarily associated with Native Americans, but can be associated with other social or cultural groups.

Prehistoric Era

The distribution and composition of vegetation communities changes through time in response to changes in climatic patterns, and this leads to changes in the distribution and nature of prehistoric cultural resources. In addition, natural processes, such as erosion and deposition, effect the evidence available for understanding successively earlier prehistoric cultures. Thus, the discussion of prehistoric resources is divided into early, middle, and late time periods. The early period covers the time from about 10,000 B.C. to 6,000 B.C., the middle period from 6,000 B.C. to about 1 A.D., and the late period from about 1 A.D. to 1492.

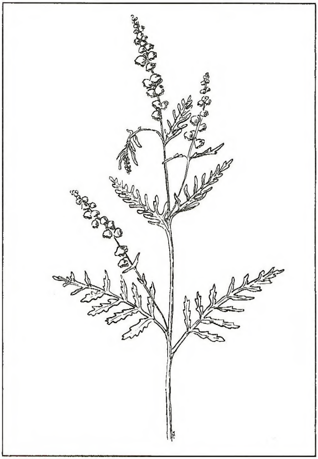
Early Period

Cultural resources from the early prehistoric period are not likely to be found in high elevation vegetation regions (such as the coniferous/deciduous forest or pinyon-juniper regions), or in other regions where topography precludes significant soil deposition, there is no major water source, or high concentrations of big game could not be supported.

Most sites from this period are interpreted as kill sites and contain extinct animal bones associated with stone tools (lance points, blades, scrapers, knives, and flake tools) used for killing and butchering. Early period campsites also are known. In addition to stone tools, campsites include hearths, broken and charred food bones, stone tool chipping debris, and hammerstones.

Middle and Late Periods

Prehistoric cultural resources from the middle and late periods are likely to be dense in vegetation analysis regions with exploitable resources, such as fish, game, and edible plants and nuts. Consequently, the pinyon-juniper, southwestern shrubsteppe, Columbia Plateau riparian areas, and plains grasslands analysis regions are expected to contain more cultural resources than other regions lacking abundant resources. Many other significant cultural



Common Ragweed

resources, however, (quarries, rock art sites, and rockshelters) are associated with variables other than vegetation. The occurrence of cultural properties may therefore be more accurately described for the vegetation analysis regions as they occur within the following major physiographic regions:

- Great Basin—Nevada, southeastern Oregon, southern Idaho, and northwestern Utah
- Columbia Plateau—Oregon and Washington east of the Cascades, and central Idaho
- Plains—eastern Montana, eastern and central Wyoming, northern and eastern Colorado, North and South Dakota, and Oklahoma
- Southwest—northern and central Arizona, New Mexico, southern Utah, and southwestern Colorado

Great Basin. The sagebrush and desert shrub regions in the Great Basin are expected to contain a moderate density of middle to late prehistoric cultural resources. Most would likely be found near water sources; however, some scattered winter camps should be found in sheltered areas. The pinyon-juniper region should contain a high density of cultural resources with an emphasis on temporary camps, storage facilities, and winter camps at lower elevations.

Middle period sites are characterized by projectile points used on spears, dense stone flake debris from making the points, rough stone tools (such as hammerstones), and masses of fire-cracked rocks from pit roasting and stone boiling. Ground stone plant milling tools (such as mortars and pestles) are common, and perishable artifacts (bone and wood tools, baskets, sandals, cordage, and so on) are found. Other sites are expected to include lithic scatters (tool making or resource exploitation), storage facilities (rock rings and caches), quarry sites, temporary camps, plant processing sites with ground stone tools), and hunting sites with dense concentrations of projectile points and flakes.

Late period artifacts of the Great Basin do not differ much from those of the middle period. Smaller projectile points characterize this period as bows and arrows replaced the spear. In the southern Great Basin, ceramics are found and function as a temporal marker for the period.

Columbia Plateau. The sagebrush, mountain/plateau grasslands, and desert shrub regions in the Columbia Plateau were exploited for root crops, grasses and shrubs during the middle to late prehistoric periods, so the density of cultural sites is expected to be low. The coniferous/deciduous forest region was exploited for berries and hunting; therefore, the density of resources in this region is also expected to be low. Within all the analysis regions, rivers and other permanent water sources would be expected to have dense cultural resources.

Salmon bones, freshwater mussel shells, and plant remains from the middle period have been found in refuse sites along rivers. Ground stone plant milling tools are common, and projectile points suggest the use of the spear thrower. By the late period bows and arrows replaced the spear, as evidenced by the smaller projectile point sizes that have been found. Otherwise, the cultural properties from the middle and late periods are not significantly different.

Plains. The plains grasslands region was exploited for edible plants and big game during the middle and late prehistoric periods. Hunting sites, gathering sites, and temporary camps are likely to be scattered throughout the region. The mountain/plateau grasslands region was used for hunting and is expected to have only sparse cultural resources. In all regions in the Plains, cultural resources should be more dense around permanent sources of water.

Middle period artifacts include freshwater mussel shells, which have been found in refuse sites along rivers. Projectile points are common, as are ground stone milling tools. Perishable artifacts include coiled and twined basketry, cordage, and an extensive bone toolkit with awls, needles, tubes, spatulas, flakers, and wrenches. Plain paddle and anvil pottery are characteristic of late period artifacts.

Southwest. The desert shrub and southwestern shrubsteppe regions in the southwest contain dense prehistoric cultural resources where mesquite and associated exploitable resources occur. In all vegetation regions of the Southwest, river valleys and other permanent water sources should contain dense cultural resources associated with horticulture.

Cultural properties of the middle period from this area are similar to those found in the Great Basin: projectile points, ground stone milling tools, and perishable artifacts, such as coiled and twined baskets, cordage, sandals, nets, reed flutes, and wooden fire drills. Burnt and broken bones, and carbonized plant remains are found in refuse sites. Painted pottery, ceramic figurines, rock art, and ritual artifacts characterize the late period.

Historic Era

The early historic era was similar to the prehistoric era and did not become distinct until significant Euro/American migration to the West began. In the

end, the traditional peoples were eliminated, assimilated, or isolated from the mainstream of the historic era.

The placement of historic cultural resources is governed by the resources extracted in response to eastern demand for raw materials and used as exchange for manufactured goods. Logging occurred primarily in the coniferous/deciduous analysis region; pinyon-juniper forests were a principal source of wood and charcoal for mines; and ranches and farms providing crops and livestock spread across valleys in the plains grasslands, sagebrush, southwestern shrubsteppe, and desert shrub regions. Cities and towns developed along lines of communication, such as rivers, trails, and roads.

Historic cultural resources cannot be further discussed by vegetation region. It is therefore difficult to predict the nature, distribution, and significance of historic cultural resources at this programmatic level; they will be assessed in BLM's local investigations of site-specific plans.

Ethnohistoric and Modern Era. The historic era blends into contemporary times in ways that preserve elements of traditional and historic cultures and lifeways. For example, Native Americans have continued traditional religious beliefs and practices and in many cases have maintained treaty rights to exploit traditional plant gathering areas and hunting rights. Other groups, such as Mormon ranchers, have also maintained traditional cultural beliefs and practices. These traditional lifeway values (BLM 1988e) can include maintaining access to vegetation communities, such as pinyon-juniper woodlands, to: (1) gather traditional foods; or (2) gather materials to make culturally significant artifacts; or (3) gather traditional plants for medicinal and religious uses. These values can also include maintaining a traditional landscape that embodies religious symbolism or is used for religious practices and may include maintaining a historic landscape that exemplifies a historic lifeway such as ranching or mining.

The distribution and nature of traditional lifeway sites will be the same as the historic or prehistoric period to which the value is attached. However, these areas will differ from historic and prehistoric properties, in that, traditional lifeway values may be associated with large diffuse areas rather that pinpointed sites.

Recreation and Visual Resources

Recreation Resources

The Bureau of Land Management manages public land and water resources for their wildlife, scenic, archeological, and historical values. These values, in turn, enhance the quality of wilderness and outdoor recreational opportunities. The Bureau's recreation program contributes to the tourist economies of the Western States and helps satisfy the growing public demand for outdoor recreation by providing opportunities on BLM-administered lands.

As with cultural resources on public lands, BLM is also responsible for maintaining an up-to-date inventory of recreation values, uses, and opportunities needed for input into and monitoring of resource management plans, recreation area management plans, and other specific planning, management, and reporting of recreational issues and concerns. Level I inventories are the base level inventories conducted on all public lands administered by BLM. Level II inventories are carried out for Special Recreation Management Areas (SRMAs) and other significant areas. The information in Level II inventories is more precise and varied in scope than the Level I inventories. Level III inventories are usually one-time reports, created in response to particular projects involving large expenditures. To be considered recreationally important, a resource must have high value for one or more recreation activities (BLM Manual 8310). Most of the recreational activities on BLM lands are resource-dependent and include hunting, fishing, sightseeing, collecting, water sports, winter sports, off-road vehicle use, and other specialized activities that are dependent on natural and cultural features found on public lands (Table 2-8).

Intensive recreation management is focused on 352 developed recreation areas and sites, constituting approximately 5 percent of BLM-administered lands. Less than 1 percent of the total acreage considered in this EIS consists of intensively managed, developed recreation areas and sites.

Most BLM public lands are managed as Extensive Recreation Management Areas (ERMAs). Management action in these areas consists primarily of providing basic information and access. ERMAs are areas where dispersed recreation occurs and where visitors have the freedom of recreational choice with minimal regulatory constraint. Significant public recreation issues or management concerns are limited in these areas, and nominal management, consistent with the Bureau's stewardship responsibility, suffices.

Special Recreation Management Areas are areas where special or intensive recreation management is needed. There are two types: congressionally recognized and administratively recognized. Examples of congressionally recognized areas are Wild and Scenic Rivers, parts of the national trail system, national recreation areas, and wilderness areas. Administratively recognized areas are those where issues or management concerns may require special

Table 2-8

Estimated Recreation Hours on BLM-Administered Lands in the Study Area

	Amount and type of recreation use (thousands of visitor hours)										
	Land-based										
	Motorized Travel										
				Site-based			Water-based			Snow and Ice-based	
State	Off-Road Vehicle	Other	Non-motorized Travel	Camping	Hunting	Other	Fishing	Boating	Other	Winter Sports	Total
Arizona	1,010	119	237	29,052	2,356	1,262	538	1,598	519	2	36,693
Colorado	929	2,669	626	3,642	5,974	621	1,538	1,245	26	222	17,492
Idaho	1,012	1,106	857	4,235	1,781	1,142	2,071	1,338	495	961	14,998
Montana, North Dakota, and South Dakota	1,929	1,756	493	3,234	2,061	289	1,711	438	56	322	12,289
Nevada	2,943	1,912	1,361	5,600	2,660	830	1,871	234	155	99	17,665
New Mexico and Oklahoma	2,389	822	718	2,979	2,855	1,588	1,176	772	51	2	13,352
Oregon[1] and Washington	794	6,500	1,101	12,137	6,063	2,505	7,287	3,637	948	537	41,509
Utah	3,151	6,419	4,677	8,450	3,655	1,758	488	4,998	105	182	33,883
Wyoming	345	1,076	308	1,842	3,090	1,545	1,325	264	24	335	10,154
TOTAL HOURS	**14,502**	**22,379**	**10,378**	**71,171**	**30,495**	**11,540**	**18,005**	**14,524**	**2,379**	**2,662**	**198,035**
Percent of Total	**7.3**	**11.3**	**5.2**	**35.9**	**15.4**	**5.8**	**9.1**	**7.3**	**1.2**	**1.3**	

[1] Data are for the State of Oregon. However, only eastern Oregon is included in the BLM program.

Source: U.S. Department of the Interior, Bureau of Land Management 1990, Table 33.

or intensive recreation management. Included in this category are those areas where visitor use may cause user conflicts, visitor safety problems, or resource damage. These more intensively used areas require direct supervision of recreational activities and of cooperative commercial and Bureau-regulated recreation operations. These high-use areas are usually identified through the Bureau's land-use planning process. Most SRMAa require vegetation treatment to maintain their appearance and to protect visitors from hazards and/or the adverse effects of poisonous plants.

Visual Resources

Visual resources consist of the land, water, vegetation, animals, and other natural or manmade features visible on public lands. Highways, rivers, and trails of the area pass through a variety of characteristic landscapes where natural attractions, such as mountain vistas, can be seen and where cultural modifications exist. Vast acreages of grass, shrub, and mountainous land provide scenic views. Particular areas of the west provide unique visual qualities and require effective management to preserve and protect them for future generations.

Individual areas of the public lands possess a variety of visual values and consequently warrant different levels of management. The BLM must therefore systematically identify and evaluate the site-specific visual values and determine an appropriate level of management. These visual values are identified through the Visual Resource Management (VRM) inventory (BLM Manual 8410-1) and are considered with other resource values in the Resource Management Planning (RMP) process.

Visual management objectives are established in RMPs in conformance with the land-use allocations made in the plan. These area-specific objectives provide the standards for planning, designing, and evaluating future management projects. The contrast rating system (BLM Manual 8431) provides a systematic means to evaluate the approved VRM objectives. It also provides a means to identify mitigating measures that can be taken to minimize adverse visual impacts. The VRM system, therefore, provides a means to identify visual values; to establish objectives through the RMP process for managing these values; and to provide timely inputs into proposed potentially surface-disturbing projects to ensure that these objectives are met.

The VRM system is designed to separate the existing landscape and a proposed project into their features and elements and to compare each part against the other to identify those parts that are not in harmony. These features include the basic design elements of form, line, color, and texture to describe the landscape and the surrounding environment. Modifications in a landscape that repeat the landscape's basic elements are said to be in harmony with their surroundings, while those that differ markedly may contrast and stand out from the natural landscape in unpleasing, nonharmonious ways. The information generated through the VRM system is to be used as a guide for field managers to decide on the amount of visual change that is acceptable and to minimize potential visual impacts.

So that visual resources can be considered when planning management, some public lands have been assigned visual resource management (VRM) classes according to scenic quality, sensitivity level, and distance zone criteria. VRM classes provide objectives designed to mitigate adverse impacts of land management practices on scenic values (BLM Manual 8400-1). VRM maps and narratives derived from inventories and evaluations of visual resources on public lands may be examined in many BLM District Offices.

Livestock

Livestock use levels are established by the Secretary of the Interior and administered through the issuance of leases and permits. On-the-ground management is commonly carried out through the development and implementation of allotment management plans (AMP). AMPs are documents that prescribe the manner in and the extent to which livestock grazing is conducted and managed to meet multiple-use, sustained-yield, economic, and other needs and objectives as determined through land use plans.

BLM lands in the States within the EIS program area are used for livestock grazing by cattle, horses, sheep, and goats. The EIS area had approximately 4.3 million head of livestock on BLM lands during 1988 that grazed on about 153 million acres of land, consuming more than 10.1 million animal unit months of forage (BLM 1988). Livestock grazing in the EIS area has been analyzed in detail by 144 site-specific grazing EISs and associated Land Use Plans.

Wild Horses and Burros

Some of the wild horses and the burros that roam the sagebrush and desert shrub regions of the American West may be descended from the animals that accompanied and escaped from the Spanish conquistadors and Jesuit missionaries during their explorations in the 16th and 17th centuries. However, most wild horses and burros are the progeny of animals that escaped or were released during the settlement of the American West during the late 19th

and early 20th centuries. Horses were an integral part of early western life. Burros also played an important role, especially with their ability to transport supplies for early prospectors and miners. Although these animals are not native to North America, they are considered "living symbols" of the historic and pioneer spirit of the West.

Under protection of the Wild Free Roaming Horse and Burro Act of 1971, the population has grown and the existence of these animals is not threatened. One of the major objectives of the Act is to keep populations at a level that will achieve and maintain a thriving natural ecological balance on the public lands. Periodic removal of the animals is the primary method at present for achieving this goal.

Management of wild horses and burros is constrained by the Act, which states that animals are to be managed at the minimum feasible level and that they may not be relocated to areas where they did not occur when the Act was passed in 1971. At the end of FY 1988, there were approximately 38,000 wild horses and 5,000 burros on almost 200 herd areas on BLM-administered public lands in Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, and Wyoming. Land-use plans completed by the end of FY 1988 called for the maintenance of approximately 27,000 wild horses and 3,700 wild burros on these herd areas.

Under normal circumstances, the diet of wild horses is composed almost exclusively of grasses. Burros have a more diverse diet, composed of grasses, herbs, and shrubs. Neither animal migrates great distances during seasonal movements within each herd area.

Special Status Plant and Animal Species

An estimated 45 of the federally listed threatened and endangered species are known to occur on public land in the 13 Western States (BLM 1988). Any action that may affect these species is subject to formal consultation with the U.S. Fish and Wildlife Service under Section 7 of the Endangered Species Act. Within the EIS area, at least 6 million acres of land (terrestrial, wetland, and riparian) and 1,800 miles of streams, lakes, or reservoirs provide important habitat for these species. The State threatened and endangered species lists contain other species in addition to those on the Federal list, and special cooperative habitat management activities are given priority to ensure their continued survival. BLM gives sensitive species special consideration to ensure that their populations do not decline to the point where listing as threatened or endangered becomes necessary.

Desert Larkspur

The discussion below serves as only an example of the possible special status species that could occur in the analysis regions. For a complete list of special status animals and plants, see Appendix H.

Sagebrush

The sagebrush analysis region is significant to the recovery of the grizzly bear and black-footed ferret. Several special status fish species are present in the sagebrush region: Borax Lake chub, cui-ui, desert dace, White River spinedace, Railroad Valley springfish, Lost River sucker, Warner sucker, and the Lahontan cutthroat trout. Federally listed threatened arthropods include the Oregon silverspot butterfly. Special status plants include the spineless hedgehog cactus and Welsh's milkweed.

Desert Shrub

Endangered or threatened species of the hot deserts include Sanborn's long-nosed bat, Sonora pronghorn antelope, Yuma clapper rail and the des-

ert tortoise (Utah and Nevada only). Federally endangered and threatened fish species include the woundfin, bonytail chub, and Gila topminnow, Sonora chub, desert pupfish, Pahranagat roundtail chub, Ash Meadows speckled dace, Pahrump killifish, Ash Meadows amaragosa pupfish, Devil's Hole pupfish, Warm Springs pupfish, Big Spring spinedace, Hiko White River springfish and White River springfish. Special status plants found in the desert shrub ecosystem include the Brady pincushion cactus, Mesa Verde Cactus, Jones cycladenia, Peebles Navajo cactus, San Rafael cactus, Ash Meadows blazing star, Ash Meadows sunray, and the Ash Meadows gumplant. The Ash Meadows naucorid (butterfly) is also found in this region.

Southwestern Shrubsteppe

Endangered or threatened species found primarily in the southwestern shrubsteppe region include Sanborn's long-nosed bat; jaguarundi; ocelot; northern aplomado falcon; Chihuahua chub; Pecos gambusia; loach minnow; desert pupfish; spikedace; Gila topminnow; Soccoro isopod; and in the Rio Yaqui drainage of southeastern Arizona, the Yaqui catfish, Yaqui chub, beautiful shiner, and Yaqui (Gila) topminnow. Special status plants found in the shrubsteppe ecosystem include the McKittrick pennyroyal, Nellie cory cactus and the bunched cory cactus, and Sneed's pincushion cactus.

Chaparral-Mountain Shrub

No endangered or threatened animal species appear to be limited to the chaparral-mountain shrub communities. Some special status plants occur in this analysis region, including the Arizona agave, Arizona cliffrose, and the Arizona hedgehog cactus.

Pinyon-Juniper

None of the endangered or threatened animal species are especially dependent on the pinyon-juniper habitat; however, the Kuenzler hedgehog cactus, Knowlton cactus, Todsen's pennyroyal, and Zuni fleabane are found primarily in this analysis region.

Mountain/Plateau Grasslands

Endangered or threatened wildlife in the mountain/plateau grasslands include the black-footed ferret, Utah prairie dog, bald eagle, whooping crane, and American peregrine falcon. Federally threatened or endangered aquatic species include the Colorado River Squawfish, humpback chub, bonytail chub, woundfish, and Gila top minnow.

Plains Grasslands

The black-footed ferret, Wyoming toad, and the Higgin's Eye pearly mussel are federally listed endangered species in the plains grasslands. Bald eagles, American peregrine falcons, whooping cranes, least terns, and piping plovers also are found in this region.

Coniferous/Deciduous Forest

The Arizona and Gila trouts inhabit small areas of the coniferous/deciduous forest region. Special status mammals include the grizzly bear, gray wolf, and the woodland caribou.

Wilderness and Special Areas

BLM administers more than 416,000 acres of federally designated wilderness lands in Arizona, Utah, Idaho, Montana, New Mexico, Oregon, and Washington. As of September 30, 1987, the EIS program area had 635 wilderness study areas (WSAs) covering about 17.5 million acres (BLM 1988). The EIS area also has many sites designated as Areas of Critical Environmental Concern (ACEC), Research Natural Areas, Outstanding Natural Areas, National Natural Landmarks, and congressionally designated National Conservation areas.

BLM uses the Area of Critical Environmental Concern designation to highlight public land areas where special management attention is necessary to protect and prevent irreparable damage to important historic, cultural, and scenic values; fish or wildlife resources; or other natural systems or processes. The ACEC designation may also be used to protect human life and safety from natural hazards. BLM identifies, evaluates, and designates ACECs through its resource management planning process. Allowable management practices and uses, mitigation, and use limitations, if any, are described in the planning document. Under current guidelines, ACEC procedures also are used to designate Research Natural Areas, Outstanding Natural Areas, and other natural areas requiring special management attention.

The Bureau also cooperates with the National Park Service in implementing the National Natural Landmark Program as it applies to BLM-administered lands. Through the National Natural Landmark Program, the Park Service designates significant examples of the Nation's ecological and geological heritage.

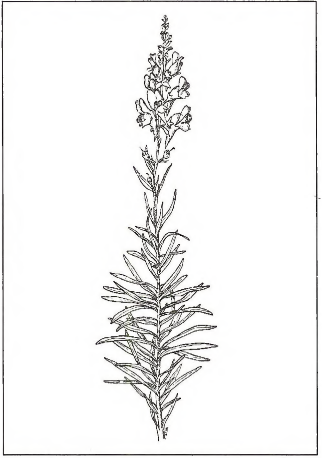
As of the end of fiscal year 1987, BLM had designated 163 ACECs encompassing more than 1.5 million acres in the 13 Western States. There were also 127 Research and Outstanding Natural Areas and 35

National Natural Landmarks on more than 1 million acres (BLM 1988).

Human Health and Safety

Background Health Risks in the Program States

This section discusses background human health risks of injuries, cancer, and other diseases for people living in the States that are included in the BLM Vegetation Treatment program. As is true for the United States as a whole, people in these States are exposed to risk from automobile accidents and many other injuries; contaminants in the air, water, and soil; chemicals in the diet; and various diseases. Occupational risks may be different from those that face the general public, depending on the work environment. Some of these risks can be quantified, while lack of data allows only a qualitative description of others. For some risks, information is available for the United States as a whole, but not specifically for the program States. In such cases, it is assumed that the United States data apply to conditions in the program States.



Yellow Toadflax

Sources of information for this section include detailed discussions by the Centers for Disease Control (CDC) of the 10 leading work-related diseases and injuries, as determined by the National Institute for Occupational Safety and Health (NIOSH) (USDHHS 1987), summaries of vital statistics for the BLM program States (U.S. Census Bureau 1987), the National Research Council's Regulating Pesticides in Food—The Delaney Paradox (NRC 1987) and Injury in America (NRC 1985), and Calabrese and Dorsey's Healthy Living in an Unhealthy World (Calabrese and Dorsey 1984). Except for certain infectious, notifiable diseases, little statistical information is available on nonfatal conditions, including cancer, that either are cured or are not the primary cause of mortality.

Risk of Diseases

Disease Incidence

According to the Centers for Disease Control (USDHHS 1987), clear causal links have been established between certain occupations and specific illnesses. For example, asbestosis among insulation and shipyard workers has been linked to their exposure to asbestos, and pneumoconiosis among coal miners has been linked to the inhalation of coal dust. Occupational exposures to some metals, dusts, and trace elements, as well as carbon monoxide, carbon disulfide, halogenated hydrocarbons, nitroglycerin, and nitrates, can result in an increased incidence of cardiovascular disease. Occupational exposure to lead and ionizing radiation may lead to reduced male fertility. Female laboratory and chemical workers show a higher rate of miscarriage than the general population. Neurotoxic disorders can arise from exposure to a wide range of chemicals, including some pesticides. Dermatologic conditions, such as contact dermatitis, infection, trauma, cancer, vitiligo, urticaria, and chloracne, have a high occurrence in the agricultural, forestry, and fishing industries, with 2,233 reported cases in 1984 and an incidence rate of 28.5 per 10,000 workers.

Disease Mortality

The mortality rates for the BLM program States are listed in Table 2-9, with some of the leading causes of death. Cerebrovascular and cardiovascular diseases are the leading causes of death in all States.

Table 2-9

Mortality per 100,000 Population and Causes of Death in BLM Program States in the Study Area

		Cause of Death			
		Diseases			
State	All	Cerebrovascular and Cardiovascular Disease	Chronic Respiratory Disease	Cancer	Accidents
Arizona	771.5	295.5	41.4	173.8	47.8
Colorado	625.7	238.5	34.9	124.4	40.1
Idaho	708.7	301.8	35.4	141.2	48.4
Montana	815.0	330.6	41.7	174.9	50.7
Nevada	772.3	306.7	39.4	180.4	43.9
New Mexico	672.8	233.3	32.9	131.7	56.9
North Dakota	821.6	381.7	26.6	177.5	33.1
Oklahoma	900.8	415.2	32.5	185.5	46.4
Oregon[1]	889.7	383.1	40.5	200.6	45.9
South Dakota	932.6	438.5	33.2	192.5	46.3
Utah	550.1	226.7	21.2	92.6	38.6
Washington	782.8	328.0	35.8	180.0	37.9
Wyoming	642.9	247.0	31.4	116.3	52.0

[1] Data are for the State of Oregon. However, only eastern Oregon is included in the BLM program.

Note: Data are for 1985.

Source: U.S. Department of Commerce, Bureau of the Census, 1987.

Risk From Injuries

Injury Incidence

Seventy million Americans incur nonfatal injuries every year. Among those less than 45 years old, injuries are the leading cause of hospitalization (NRC 1985).

NIOSH estimates that in the United States about 10 million traumatic work-related injuries occur annually (USDHHS 1987). Several chronic injuries are directly linked to the type of work done. For example, vibration syndrome affects up to 90 percent of workers using chippers, grinders, chain saws, jackhammers, or other handheld power tools, causing blanching and reduced sensitivity in the fingers (USDHHS 1987). Noise-induced hearing loss affects 17 percent of U.S. production workers who are exposed to noise levels of 80 decibels or more on a daily basis (USDHHS 1987).

Injury Mortality

Approximately 140,000 Americans die from injuries annually. Of the 94,072 deaths from unintentional injury in 1982, 47.5 percent were caused by motor vehicle accidents; 12.8 percent, falls and jumps; 6.8 percent, drowning; 3.7 percent, poisoning; and the other 29.2 percent, a wide variety of causes (NRC 1985). Injuries are the primary cause of death among young adults and children. From the ages of 15 to 24, injuries cause almost 80 percent of the fatalities (NRC 1985). Injuries cause about 10,000 occupational fatalities per year. Some of the causes include highway motor vehicle accidents (34.1 percent in 1980 to 1981), falls (12.5 percent), industrial vehicle or equipment accidents (11.4 percent), and fires (3.4 percent). Workers in the mining and quarrying industry had the highest rate of traumatic deaths, at 55 per 100,000 workers. Agriculture had a rate of 52 deaths per 100,000 workers, while trade had only 5 deaths per 100,000 workers (USDHHS 1987).

Risk of Cancer

Cancer Incidence

Nationwide, the chance of developing some form of cancer during one's lifetime is about 1 in 4 (Calabrese and Dorsey 1984, NRC 1987). The causes of cancer development are many, including occupational exposure to carcinogens, environmental con-

taminants, and substances in food. In the United States, one-third of all cancers have been attributed to tobacco smoking (Chu and Kamely 1988). It is estimated that work-related cancers account for anywhere from 4 to 20 percent of all malignancies (USDHHS 1987); however, it is difficult to quantify the information because of factors such as long intervals of time between exposure and diagnosis, personal behavior patterns, job changes, exposure to other carcinogens, and difficulties in documentation.

Cancer Mortality

Based on the data in Table 2-9, cancer accounted for 9 to 20 percent of 1985 fatalities in the BLM program States. These figures are reflective of the national cancer mortality figures in which cancer accounted for 19 percent of 1985 deaths in the United States (USDC 1988).

Social and Economic Resources

Social Resources

The EIS program area is more sparsely populated than the rest of the United States, and a greater proportion of the residents live in rural areas. These Western States have an average of 22 people per square mile, compared to the national average of 68 per square mile (Table 2-10). Four of the program States—Montana, North and South Dakota, and Wyoming—are among the least densely populated in the western area, with between 5 and 10 people per square mile. Washington and Oklahoma have the highest population density, with 67 and 48 inhabitants per square mile, respectively. The rural population is 32 percent, significantly greater than the national average of 26 percent (USDC 1984). Approximately 5 percent of the region's inhabitants are rural farm residents.

Table 2-10

Population Distribution and Density of the States in the Study Area

	Population (1986)		Distribution (1980) (Percent)			Density (1986)
State	Total (thousands)	Rank	Urban Total	Rural Total	Farm	Per Square Mile Land Area
Arizona	3,319	2	83.8	16.2	0.5	29.2
Colorado	3,267	4	80.6	19.4	2.0	31.5
Idaho	1,002	8	54.0	46.0	7.3	12.2
Montana	819	10	52.9	47.1	7.4	5.6
Nevada	963	9	85.3	14.7	0.7	8.8
New Mexico	1,479	7	72.1	27.9	1.5	12.2
North Dakota	679	12	48.8	51.2	15.9	9.8
Oklahoma	3,305	3	67.3	32.7	4.3	48.1
Oregon	2,698	5	67.9	32.1	3.0	28.0
South Dakota	708	11	46.4	53.6	16.3	9.3
Utah	1,665	6	84.4	15.6	1.3	20.3
Washington	4,462	1	73.5	26.5	2.0	67.1
Wyoming	507	13	62.7	37.3	4.1	5.2
Average:						
Western States			67.7	32.3	5.1	22.1
United States			73.7	26.3	2.5	68.1

Sources: U.S. Department of Commerce, Bureau of the Census 1987, Table 21; and U.S. Department of Commerce, Bureau of the Census 1984, Table 2.

Economic Resources

In 1980, agriculture, forestry, fisheries, and mining industries accounted for nearly 10 percent of all employment in the 13 Western States (Table 2-11). In Wyoming more than 20 percent of the workers depend on these industries for jobs, while in Nevada only 3 percent are employed in these resource-based industries.

Domestic livestock operations based on public lands play a vital role in the economic prosperity of many communities in the Western States. Many residents earn their livelihoods in livestock production and meat processing industries or are employed in industries using byproducts to make leather, pet food, textiles, and other commodities. Others are employed by businesses that supply goods and services to these industries and by railroads and trucking firms that move products to markets across the country.

Sagebrush

More than 90 percent of all land in the sagebrush region is rangeland (USDA 1981). A large part of the land not federally owned is private farms and ranches. Irrigation is practiced where water is available and soils are suitable. The Snake River and its tributaries irrigate more than 25 percent of this region, supporting some of the most productive agricultural lands in the Western United States. Small acreages are used to grow feed crops and some wheat. Peas, beans, and sugarbeets also are grown.

Livestock production is the primary agricultural activity on the vast BLM lands in this region. In the Snake River Plain, opportunities exist to increase forage production with improved management and conditions. Open forests on high mountain slopes also provide important habitats for wildlife and livestock grazing.

Desert Shrub

Approximately 75 percent of the desert shrub analysis region is owned by Federal and local governments. The remainder is in private ownership and consists mostly of farms and ranches. Livestock grazing is an important component of this analysis region. Citrus fruit, dates, grapes, sugarbeets, many kinds of vegetables, small grains, hay, and pasture grasses are grown.

Southwestern Shrubsteppe

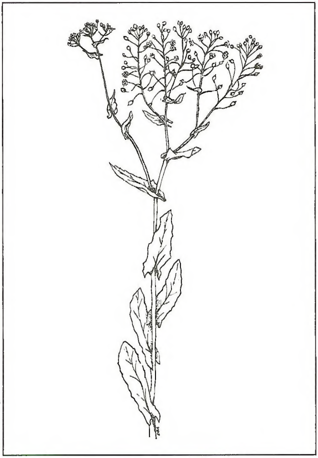
Use of land area in the southwestern shrubsteppe region is dependent upon the local development of ground-water resources. In those areas with water-well development, irrigation farming is practiced. Much of the area is used as rangeland for grazing livestock.

Chaparral-Mountain Shrub

The interior and southwestern portions of the chaparral-mountain shrub region are largely used for livestock grazing. Lands in these places that are suitable for crops are most often used for producing forage crops.

Pinyon-Juniper

The pinyon-juniper ecosystem is used for grazing and wood products, such as Christmas trees, fence posts, and cord wood.



Hoary Cress

Table 2-11

Employment by Industry in the States in the Study Area

State	Agriculture, Forestry, Fisheries, and Mining Number	Percent	Construction Number	Percent	Manutacturing Number	Percent	Transportation and Communications Number	Percent	Retail and Wholesale Trade Number	Percent	Business, Finance, Insurance, and Real Estate Number	Percent	Repair and Personal Services Number	Percent	Professional Services Number	Percent	Public Administration Number	Percent	TOTAL
Arizona	59,396	5.3	90,381	8.1	161,302	14.5	73,779	6.6	246,094	22.1	77,266	6.9	108,227	9.7	223,845	20.1	72,980	6.6	1,113,270
Colorado	78,817	5.8	107,063	7.9	192,305	14.1	108,668	8.0	298,526	21.9	96,725	7.1	127,966	9.4	274,880	20.2	77,067	5.7	1,362,017
Idaho	43,959	11.5	26,718	7.0	53,455	13.9	28,789	7.5	84,795	22.1	20,755	5.4	33,901	8.8	68,544	17.9	22,736	5.9	383,652
Montana	43,360	13.2	23,035	7.0	24,286	7.4	29,417	9.0	73,862	22.5	16,162	4.9	25,161	7.7	71,057	21.6	21,976	6.7	328,316
Nevada	12,033	3.0	31,428	7.9	23,353	5.9	30,265	7.6	75,379	18.9	23,884	6.0	121,430	30.5	55,103	13.8	25,691	6.4	398,566
New Mexico	47,514	9.3	42,769	8.4	37,737	7.4	37,362	7.4	105,553	20.8	26,445	5.2	58,336	11.5	109,492	21.5	43,030	8.5	508,238
North Dakota	47,516	17.4	18,999	7.0	15,877	5.8	20,935	7.7	63,801	23.4	12,493	4.6	17,741	6.5	61,280	22.5	13,978	5.1	272,620
Oklahoma	114,171	8.9	92,856	7.2	214,779	16.7	96,043	7.5	269,426	20.9	68,873	5.3	99,492	7.7	253,144	19.7	79,073	6.1	1,287,857
Oregon	55,001	4.8	73,250	6.4	222,017	19.5	81,621	7.2	256,497	22.5	71,228	6.3	86,975	7.6	234,834	20.6	57,002	5.0	1,138,425
South Dakota	51,018	17.2	17,464	5.9	28,555	9.6	18,005	6.1	65,256	22.0	13,856	4.7	20,415	6.9	65,061	21.9	17,049	5.7	296,679
Utah	32,414	5.5	41,797	7.1	92,557	15.8	43,979	7.5	123,835	21.1	34,316	5.9	45,792	7.8	120,804	20.6	50,427	8.6	585,921
Washington	72,723	4.1	122,396	6.8	349,977	19.5	139,132	7.8	394,733	22.0	111,485	6.2	152,137	8.5	363,768	20.3	88,003	4.9	1,794,354
Wyoming	43,857	20.2	22,282	10.3	11,821	5.4	19,946	9.2	41,867	19.3	8,794	4.0	16,859	7.8	39,546	18.2	12,402	5.7	217,374
TOTAL	701,779		710,438		1,428,021		727,941		2,099,624		582,282		914,432		1,941,358		581,414		9,687,289
Average	53,983	9.7	54,649	7.5	109,848	12.0	55,995	7.6	161,510	21.5	44,791	5.6	70,341	10.0	149,335	19.9	44,724	6.2	

Source: State Demographics, Dow Jones-Irwin 1983.

Plains Grasslands

The plains grasslands region is considerably more arid than the tallgrass region to the east. Progressing west and south within this region, livestock grazing on native as well as improved rangeland becomes increasingly important. To the east and where sufficient moisture exists for agriculture, the principal crops are wheat, grain sorghum, sugarbeets, soybeans, corn, and other feed grains. Cotton is also grown in irrigated areas in the southern part of the region.

Mountain/Plateau Grasslands

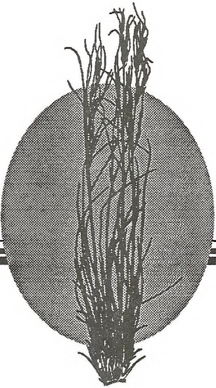
Most of the mountain/plateau grassland region is used for grazing sheep and cattle; much of the grazing land is federally owned. Irrigated croplands are found along the valleys of major streams. Alfalfa, grain, corn, and hay for livestock feed are the main crops; but fruits, vegetables, and other cash crops are also grown. Land-use problems resulting from declining water tables and short supply of irrigation water are common. Overgrazing contributes to the invasion of brushy vegetative species and gully erosion.

Coniferous/Deciduous Forest

A large percentage of the coniferous/deciduous forest region is federally owned; the remainder is farms, ranches, and other privately owned land. Lumber is a principal industry, and large tracts of land in the Rockies are controlled by commercial timber companies. Forests and woodland areas provide important wildlife habitats and grazing for livestock. Mining occurs in Idaho, western Montana, and the Cascade Mountains. Cropland accounts for only a small part of the acreage in this region.

Chapter 3

Environmental Consequences



CHAPTER 3

ENVIRONMENTAL CONSEQUENCES

INTRODUCTION

This chapter discusses the impacts of the Bureau of Land Management's proposed vegetation treatment program, described in Chapter 1, on the natural and human environment detailed in Chapter 2 vegetation, climate and air quality, geology and topography, soils, aquatic resources, fish and wildlife, cultural resources, recreation and visual resources, livestock, wild horses and burros, special status species, wilderness and special areas, human health and safety, and social and economic resources. It must be stressed that, because this is a programmatic EIS covering a wide variety of treatment methods over a broad land area, the analysis addresses impacts at a fairly general level. (Site-specific impacts will be addressed in Environmental Assessments tiered to this document.)

The first section of this chapter describes the potential impacts each vegetation treatment method would have on those environmental components.

The basic outline of the chapter is as follows:

Section 1: Impacts of the Vegetation Treatment Methods

- Impacts on a Resource Element (e.g., soils)
  - Impacts of Manual Methods
    - Impacts in the Sagebrush Region
    - Impacts in the Desert Shrub Region
    - Impacts in the Coniferous/Deciduous Forest Region

    ...

  - Impacts of Mechanical Methods
    - Impacts in the Sagebrush Region

    ...

  - Impacts of Biological Methods
  - Impacts of Prescribed Burning
  - Impacts of Chemical Methods
- Impacts on the Next Resource Element (e.g., vegetation)
  - Impacts of Manual Methods

    ...

Impacts are discussed for each treatment method under each component (soils, vegetation, etc.). Impacts for each method are discussed within each vegetation analysis region for those environmental components for which the impacts are likely to vary from analysis region to analysis region. The impacts discussion is not broken down to the vegetation analysis region level for those components not likely to vary significantly at that level. The treatment methods may have short-term impacts, occurring only briefly immediately after an area is treated; long-term impacts, lasting for months or years after a treatment; and cumulative impacts, operating in conjunction with the impacts of other nearby treatments or over time if a given locality receives a number of treatments.

The second section of the chapter discusses the effects of the treatment program alternatives, comparing the probable effects of using a combination of treatment methods in implementing the proposed action with the likely effects of the four alternative programs, including "no action."

Section 2: Impacts of the Treatment Program Alternatives

- Impacts on a Resource Element (e.g., soils)
  - Impacts of the Proposed Program (Alt. 1)
    - Impacts in the Sagebrush Region
    - Impacts in the Desert Shrub Region
    - Impacts in the Coniferous/Deciduous Forest Region

    ...

  - Impacts of No Aerial Application of Herbicides (Alt. 2)
    - Impacts in the Sagebrush Region

    ...

  - Impacts of No Use of Herbicides (Alt. 3)
  - Impacts of No Use of Prescribed Burning (Alt. 4)
  - Impacts of "No Action" (Alt. 5)
- Impacts on the Next Resource Element (e.g., vegetation)
  - Impacts of the Proposed Program (Alt. 1)

This EIS addresses what may be termed cumulative impacts from two perspectives. First, because treatments are done on individual sites, the EIS addresses the potential adverse effects and benefits of the treatments done on the numerous program sites across the EIS area and the effects over time of those collective treatments. Again, this is done at a general level because only at the site-specific level, addressed in particular Environmental Assessments, can impacts at specified individual locations be evaluated. This first type of discussion will be found throughout the text of this chapter. Second,

the EIS addressed cumulative impacts according to Council on Environmental Quality (CEQ) regulations (40 CFR 1508.7) as the incremental impact the proposed BLM program would have on the environment of the EIS area when added to past, present, or reasonably foreseeable future actions of other agencies or individuals. Where cumulative impacts were addressed, this analysis is found in separate resource element impact sections.

Principal aspects of the human environment that are not likely to be affected at all—climate, geology, topography—are not discussed in detail. Because 84 percent of BLM's proposed program consists of rangeland treatments, the discussion focuses on the effects of those treatments.

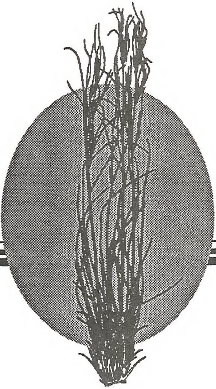
To determine the effects of the herbicides on human health, wildlife, and aquatic organisms, an herbicide risk assessment was conducted. Appendix E describes in detail the hazards of the 19 herbicides and of diesel oil and kerosene; estimates human, wildlife, and aquatic species exposures to the chemicals from application formulations commonly used on rangelands, forest lands, oil and gas sites, rights-of-way, and recreation sites; and analyzes the risk of adverse effects from those exposures. The results of the herbicide risk assessment are summarized in this chapter in the sections on Fish and Wildlife and on Human Health and Safety. The risk to human health from the fire and smoke from prescribed burning was analyzed in a prescribed burning risk assessment presented in Appendix D. The results are presented in this chapter in the section on Human Health and Safety.

For analyses in this chapter, the following assumptions were made: (1) that BLM will have the funding and personnel to implement the final decision, (2) that all standard operating procedures described in Chapter 1 and Appendixes C, E, and J will be applied, and (3) that the types and amounts of vegetation treatments will be applied as shown in Table 1-1 (Chapter 1).

Chapter 3

Section 1

Impacts of the Vegetation Treatment Methods



SECTION 1

IMPACTS OF THE VEGETATION TREATMENT METHODS

VEGETATION

Vegetation treatments would have beneficial and adverse effects on terrestrial vegetation within the EIS area. Target and nontarget vegetation in treated areas would be directly affected. The degree to which vegetation would be affected would depend on the types of treatment used and the number of acres treated under each alternative (see Table 1-1). The overall effect of treating vegetation would be to achieve the desired successional stage, to create a more stratified age structure for wildlife habitat improvement and fuel hazard reduction, to accelerate succession for forest management, and to reduce or eliminate populations of undesirable species in noxious weed eradication programs.

Mechanical treatments affect plants differently depending upon their vegetative reproduction capabilities. In general, woody plants have more negative effects than herbaceous plants. Biological methods will affect target and nontarget vegetation depending upon the abundance of the particular plant species and palatability to animals. Prescribed burning may greatly increase the growth of herbaceous plants and can help prevent wildfire. Vegetation effects of herbicides will depend on how closely related target and nontarget species are, the selectivity of the herbicide, and the application rate. The effects of some vegetation treatment methods on vegetation and soils are summarized in Table 3-1.

Table 3-1

Generalized Influence of Selected Brush Control Treatments on Vegetation and Soils

Kind of Brush Control	Influence on Vegetation: Woody Plants	Influence on Vegetation: Herbaceous	Influence on Soils
Selective Herbicides	Removes canopies; some plants resprout; dead plants left in place.	Grass cover typically increases; forbs reduced for growing season; composition changes toward grass dominance; unless grass is target, then composition may go to shrubs/ broadleaved species.	No physical effects.
Mechanical Top Removal			
Shredding	Removes top growth; many species regrow vigorously.	Grass cover increases, but improvement may be short term.	Minimal physical effects; woody debris mulches surface.
Roller Chopping	Generally same as for shredding.		Some imprinting of soil by roller blades; woody debris mulches surface.
Hand Slashing	Generally same as for shredding.		Minimal physical effects.

Table 3-1 (Continued)

Generalized Influence of Selected Brush Control Treatments on Vegetation and Soils

Kind of Brush Control	Influence on Vegetation		Influence on Soils
	Woody Plants	Herbaceous	
Entire Plant Removal			
Grubbing	Individual plants extracted; little or no regrowth.	General increase in herbaceous species.	Disturbance depends on woody plant density; pits left by extraction trap water.
Bulldozing	Individual plants extracted; little or no regrowth; small or limber plants may remain.	Grass cover increases in interspaces; forbs increase in disturbed areas. May get weedy species initially, but should revegetate to perennials.	Disturbance depends on woody plant density, but can be extensive; pits left by dozed plants trap water.
Chaining/Cabling	Large woody plants extracted; small or limber plants remain.	Grasses/forbs generally increase; seeding often used to expedite cover.	Disturbance depends on chain modification; pits left by extraction of larg plants; soil surface may be further disturbed by raking, or debris may be left in place.
Root Plowing	Woody plants removed by severing below ground line.	Grasses may be reduced; short-term increases in forbs, initial increase in bare soil; seeding often used to expedite cover.	Subsoil disturbance depth depends on woody species, surface disturbances may be extreme.
Disk Plowing	Woody plants mulched into the surface soil.	Grasses are reduced; short-term increase in forbs; initial increase in bare soil; seeding used to establish cover.	Complete surface soil disturbance.
Prescribed Burning	Short-term reduction in woody plant canopies; some woody plants often rapidly regrow.	Varies, but short-term decrease in herbaceous cover; fine mulch consumed. May be flush of herbaceous growth the same year because of an increase in available nutrients.	No soil disturbance but soil surface "bared" usually for a short time, depending largely on postburn weather.

Manual Methods

Manual methods are highly labor intensive and require periodic retreatment ranging from every 3 weeks during the growing season to annually, depending on the target species. These methods have been somewhat successful in controlling annuals and biennials in noxious weed control and vegetation removal along rights-of-way, recreation areas, pipelines, and so on. However, manual treatments have proven inefficient in controlling established creeping perennials in these situations. Manual methods are impractical for large-scale rangeland improvement projects and prescribed burning pretreatment.

With manual vegetation treatment, some degree of weed control would be achieved, but most weeds (including many noxious species) would spread as a result of ineffective control efforts. Undesirable vegetation would again increase. However, manual methods of vegetation treatment are selective. Nontarget species should not be adversely affected. Nontarget plants would benefit from reduced competition for water and nutrients.

Mechanical Methods

Direct effects on target and nontarget vegetation from mechanical treatments depend on how a particular method affects a species at its growing points and its vegetative or sexual reproductive abilities (Sosebee 1983). Indirect effects on nontarget vegetation depend on the availability of resources (water, minerals, light) previously used by the target species.

Because woody plants invest greater energy in perennial, above-ground structures, such as branches and twigs, top removal treatments generally have greater negative effects on woody plants than on herbaceous species, which annually replace their canopies. However, many woody plants can sprout from basal buds and may be reduced in size but are not killed by mechanical top removal. Britton and Wright (1983b) have listed sprouting response caused by mechanical control of various brush species (Table 3-2). Woody and herbaceous plants that reproduce vegetatively are tolerant of top removal by mechanical methods. Many species are flexible enough to bend rather than break during mechanical treatment.

Table 3-2

Sprouting Response of Brush Species after Mechanized Treatment in the Principal Rangeland Types in North America

Vegetation Type	Sprouters	Nonsprouters
Shortgrass Prairie	Mesquite Yucca Shinnery oak	
Mixed Prairie	Mesquite All oaks Redberry juniper Sumac Algerita[1] Prickly pear Cholla	Eastern red cedar Ashe juniper
Tallgrass Prairie	Sumac Western snowberry Lead plant Shrub oak Shinnery oak	Eastern red cedar
Fescue Prairie	Aspen Prairie rose Serviceberry Silverberry	
Palouse Prairie	Rabbitbrush	Big sagebrush
Semi-Desert Grass-Shrub	Velvet mesquite False mesquite Velvet-pod mimosa Algerita[1] Fourwing saltbush Winterfat	Ocotillo Wheeler sotol Desert blackbrush Sagebrush

Table 3-2 (Continued)

Sprouting Response of Brush Species after Mechanized Treatment in the Principal Rangeland Types in North America

Vegetation Type	Sprouters	Nonsprouters
Semi-Desert Grass-Shrub (continued)	Skunkbush sumac Wright baccharis Shinnery oak Creosote bush	
Sagebrush-Grass	Greasewood Rabbitbrush Curlleaf mahogany	Big sagebrush Low sagebrush
Serviceberry	Snowbrush True mountain mahogany[1] Silver sagebrush Three-tip sagebrush[1] Horsebrush Antelope bitterbrush[1]	
Arizona Chaparral	Shrub live oak Sugar sumac Skunkbush sumac Redberry Catclaw Emory oak Yerbasanta True mountain mahogany Western mountain mahogany Hairy mountain mahogany	Desert ceanothus Mexican cliffrose Deerbrush Pointleaf manzanita
Oakbrush	Gambel oak Chokecherry Wood rose Snowberry Ninebark Serviceberry	Mountain lover Creeping barberry
Pinyon-Juniper	Serviceberry Wright silktassel Shrub live oak Antelope bitterbrush[1] Skunkbush sumac True mountain mahogany Chokecherry Winterfat Mockorange Snowberry Algerita[1] Rabbitbrush Four-wing saltbush Horsebrush Desert bitterbrush Curlleaf mountain mahogany[1] Broom snakeweed Mountain lover Yucca Fringed sagebrush	Big sagebrush Black sagebrush Desert Blackbrush

[1] Weak sprouters; antelope bitterbrush can sprout vigorously following burns at its upper elevational limits.

Source: Britten and Wright 1983.

Sexual reproductive characteristics are important in determining plant tolerance to mechanical treatments in general but are especially important in determining response to root cutting or removal. Characteristics associated with tolerance to mechanical treatments may include abundant seed production and dispersal, long-term seed viability in the seedbank, and rapid germination and seedling growth when environmental resources are available (Harper 1977). Top removal methods generally do not kill and may even spread more limber and sprouting species, but may greatly reduce brittle and nonsprouting species. Methods that remove the entire plant by plowing or cutting roots have the greatest effect on nontarget species and generally require subsequent revegetation.

Sagebrush

For more than 50 years, sagebrush-dominated rangelands have been treated by many different mechanical control methods (Blaisdell et al. 1982). Target species have generally been different subspecies of big sagebrush, as well as species of rabbitbrush; however, not all species of sagebrush can be considered undesirable (Johnson 1987). Most nontarget species are perennial brushgrasses and forbs but may also include shrubs such as bitterbrush and fourwing saltbush.

Railing and brush beating or shredding cause little damage to herbaceous species; however, these methods may release associated undesirable shrubs that sprout, such as rabbitbrush, horsebrush, and greasewood (Blaisdell et al. 1982, Roundy et al. 1983). In addition, herbaceous weeds, such as cheatgrass, halogeton, and medusahead may be released in the absence of desirable species when these species are removed during sagebrush control (Lancaster et al. 1987). Top control methods increase production of associated herbaceous species because sagebrush cover is reduced and soil water availability is increased (Sturges 1975). Grass production generally doubles after sagebrush removal and methods other than plowing and disking do not greatly change herbaceous composition. Plowing or disking are most recommended in areas with little herbaceous understory in which soil disturbance would help to prepare a seedbed for revegetation (Blaisdell et al. 1982, Cluff et al. 1983).

Adequate precipitation and favorable soil characteristics are important for successful revegetation following sagebrush control. Revegetation following plowing of sagebrush will result in dominance by weedy annual species if conditions are not conducive to desired species (Shown et al. 1969).

Although data are scarce, it should be expected that desirable shrubs associated with sagebrush, such as bitterbrush, cliffrose, western serviceberry, and fourwing saltbush, could be damaged by mechanical treatments, especially plowing. Canopy treatment methods, however, such as rotomowing, may actually stimulate bitterbrush growth if done at the proper height (Jones 1983).

In summary, mechanical treatments that control sagebrush by cutting or breaking the canopy tend to increase understory herbaceous species. Plowing of sagebrush can reduce desired species and is generally done where an understory of desired vegetation is inadequate to revegetate naturally. Desired results are achieved either by release of understory vegetation existing on the site through decreased competition with sagebrush, or by reseeding sites on which pre-treatment understory is inadequate to revegetate the site.

Desert Shrub

Mechanical or other vegetation control methods are generally not recommended on saltdesert shrubland or blackbrush and Mojave-Sonoran desert shrublands. Revegetation is usually necessary to increase the cover of desirable species on these lands, but successful revegetation is limited by low and erratic precipitation (Bleak et al. 1965, Jordan 1981, Cox et al 1982, Blaisdell and Holmgren 1984, Roundy and Young 1985). Mechanical treatments of most of these shrublands tend to decrease the cover of shrubs, including desirable saltbushes, and increase the cover of annual weeds, such as halogeton and Russian thistle. Because establishment of perennial vegetation in desert shrublands may require successive years of unusually high precipitation, natural revegetation is limited and vegetation disturbance is not recommended.

Southwestern Shrubsteppe

Many woody species in the southwestern shrubsteppe are able to resprout after top removal. Methods such as chaining and cabling may reduce large trees but increase smaller trees and undesirable shrubs, such as mesquite and species of acacia (Martin 1975). Chaining, cabling, and roller chopping, which pull over or break the canopy of woody plants on southwestern shrubsteppe ranges, do not destroy remnant stands of perennial grasses but may kill some herbaceous plants (Martin 1975). Removal of cholla does not necessarily increase production of herbaceous vegetation (Pieper 1971); however, removal of creosotebush and tarbush may greatly increase diversity and cover of other shrubs, grasses, and forbs (Beck and Tober 1985).

Rootplowing is the most effective method of mechanically controlling undesirable species in the southwestern shrubsteppe, but it also kills most per-

ennial grasses and forbs that are unable to reproduce vegetatively (Vallentine 1980). Because root-plowing may kill more than 90 percent of the vegetation (Herbel 1984a), it is generally recommended only in conjunction with revegetation (Vallentine 1980). In areas of insufficient precipitation, revegetation may not be successful. Where precipitation is sufficient to permit successful revegetation, root and disk plowing increases the density and production of perennial grasses on southwestern shrub-steppe (Herbel et al. 1973, Cox and Jordan 1983, Cox et al. 1986).

In summary, nonplowing mechanical control methods may temporarily reduce woody species and increase herbaceous vegetation. Woody species will resprout and eventually redominate. Root-plowing reduces both woody and herbaceous vegetation but, when combined with revegetation, may increase production of and diversity of herbaceous species.

Chaparral-Mountain Shrub

Chaparral treatments are used to reduce woody vegetation and increase herbaceous vegetation for increased forage or water yield. Methods that reduce woody vegetation canopies have limited success because most chaparral species resprout from buds in the base, rhizomes, or roots (Cable 1975). Root-plowing is the most recommended mechanical treatment to control chaparral species and must usually be followed by revegetation because understory herbaceous vegetation is usually lacking or is reduced by plowing disturbance. Plowing and seeding of adapted grasses reduce woody vegetation and increase herbaceous production (Cable 1975). Mechanical treatments without revegetation would be expected to decrease shrub cover for a short time, but vegetation should quickly return to predisturbance conditions with the growth of resprouted shrubs.

Pinyon-Juniper

Mechanical treatment methods have been used extensively in pinyon-uuniper woodlands. Pinyon and juniper trees have extensive root systems and use soil water and nutrients more efficiently than most shrubs and herbaceous species (West 1984). The competitive ability of these trees allows them to dominate many sites to the eventual exclusion of understory species and to rapidly redominate when only partially controlled (Tausch and Tueller 1977, West 1984). Vegetation response to mechanical treatments is related to the type and amount of tree control, the plant species diversity of the site at treatment, and site climatic and soil conditions. Bulldozing, tree crushing, roller chopping, cabling, and most commonly, chaining are used to reduce pinyon-juniper cover and increase shrub and herbaceous forage.

Single chaining or cabling kills older trees and may result in short-term increases in herbaceous production, but young trees are not killed and rapidly regrow, returning the site to predisturbance composition and production (Aro 1971, 1975). Double chaining kills more trees than single chaining and results in greater release of herbaceous vegetation (Aro 1971, 1975). Windrowing is generally followed be revegetation and is most effective in converting woodland to grassland, although success depends on establishment of seeded species (Evans 1988). Bulldozing may be done to avoid damage to desirable shrubs, such as bitterbrush and cliffrose, and still reduce trees.

Successional patterns and production of different species after mechanical treatment vary greatly, depending on the site (West 1984). Vegetation response to mechanical treatments depends on the successional stage at the time of treatment and the type of plants that are killed. Production of most grass species (blue and sideoats grama, prairie junegrass, squirreltail, mutton bluegrass, and western wheatgrass) may increase after tree control. Forbs (ragweed, aster, redroot eriogonum, annual goldeneye, and sunflower) will also increase. Some cool-season grasses may actually have higher production under scattered alligator juniper trees than in the open (Clary and Morrison 1973). Removal of trees in this situation is not recommended because they help maintain cool-season grasses in the community.

Vegetation response to mechanical removal of pinyon and juniper has been found to depend on associated soils in some studies. O'Rourke and Odgen (1969) reported two to four times the production of perennial grasses on sites in Arizona with moist soil than on dry soil sites after mechanical removal of pinyon and juniper. Native perennial grasses (sideoats, blue, and hairy gramas), many forbs (sunflower, sweetclover, globe mallow, and spurge, for example), half shrubs (snakeweed and buckwheat), and shrubs (shrub live oak, manzanita) increased yields on some sites after mechanical removal of Utah juniper (Clary 1971). Areas initially lacking native perennial grasses did not advance in succession but were dominated by snakeweed and annual goldeneye. Increases in herbage production after mechanical treatment of pinyon-juniper trees in Arizona were greatest on sites with high annual precipitation, high pretreatment tree canopy, or high nitrate and nonlimestone soils (Clary and Jameson 1981). Vegetation composition of perennial grasses increased, while half-shrub vegetative composition decreased, and that of forbs changed little after tree control. Authors concluded that the site potential must be carefully considered in estimating understory response from pinyon-juniper control.

In summary, mechanical control of pinyon and juniper generally results in an increase in herbaceous annuals and perennials, as well as shrubs. This response is short-lived where trees are partially controlled and may be limited on dry sites because of low precipitation or shallow soils. Post-treatment vegetation is generally characterized by vegetation present in the community when it was treated. Communities lacking desirable herbaceous and shrub species generally continue to be dominated by existing weedy species, such as snakeweed and cheatgrass, unless revegetation is successfully applied. Mechanical treatment should be used to completely kill trees on sites with sufficient desirable species, precipitation, and soil depth to maximize desirable understory vegetation response.

Plains Grassland

The objective of mechanical treatment on plains grasslands has been to reduce cover of warm-season species, increase infiltration and nutrient cycling by breaking up compacted soils or sod-bound vegetation, and increase the production of cool-season grasses. Mechanical treatments will usually achieve these objectives, depending on the limiting factors of a particular site and the amount of disturbance. Where soils are fine-textured and have low infiltration rates, mechanical treatments may increase cool-season herbage production. Greater forage production was associated with greater spring soil water content on the furrowed areas. Ripping and contour furrowing of fine-textured loamy soils increased herbage production more in a drought year than in a year with normal precipitation (Griffith et al. 1985).

Furrowing of coarse-textured soils with high infiltration rates does not generally increase water storage and forage production (Valentine 1947, Branson et al 1966). However, mechanically disturbing sod-bound vegetation on sandy soils may increase herbaceous production. Plowing of clayey and sandy soils may initially decrease, then increase total herbaceous production (Rauzi 1975). Mechanical treatments may increase nutrient cycling and production of western wheatgrass as it reinvades areas of native grasses on sandy soils (Wright and White 1974).

In summary, mechanical treatments generally increase production of perennial grasses and forbs, increase infiltration and nutrient cycling, and may decrease production of warm-season grasses on plains grasslands.

Mountain/Plateau Grasslands

Mechanical treatments of mountain grasslands have been reported only as a precursor to revegetating grasslands dominated by undesirable herbaceous weeds. Shrubs such as big sagebrush and rabbitbrush have invaded these grasslands (Yoakum et al. 1969), where soils have become drier as a result of channel cutting and a lowered water table (Eckert et al. 1973a). Mechanical methods, such as rotobeating, railing, or cabling, have not been reported in the literature but could be used to destroy canopies of shrubs invading mountain or plateau grasslands. Such methods do not appreciably disturb the soil and would have limited impact on herbaceous plants that bend easily and are not uprooted, such as rushes and sedges, perennial grasses, and forbs.

Information on vegetation response of mountain grasslands to plowing, furrowing, and seeding is mainly from work done in Nevada (Eckert et al. 1973b), Eckert 1975). In those studies, plowing reduced production of cheatgrass and sedge and prepared a seebed for revegetation by desired species. Perennial grasses, such as various wheatgrasses, bromegrass, and fescue, in addition to legumes (alfalfa and sainfoin), were successfully established in furrows on plowed grasslands. These practices converted the vegetation from dominance by herbaceous weeds, such as cheatgrass and povertyweed, to desirable herbaceous perennial grasses and forbs. Production of native and seeded grasses and seeded legumes was high after treatment.

Coniferous/Deciduous Forests

Mechanical treatments aid in the germination of grasses and hardwoods. These treatments would also increase sprouting of shrubs, such as kinnikinnick and Gambel oak, which after repeated treatment, may form dense hedges. Mechanical treatment alone could result in stands of shrubs surrounded by dense cover of grasses and forbs (Newton and Dost 1981).

Biological Methods

Biological methods of vegetation treatment that may be considered for BLM use include grazing animals, insects, and pathogens. Grazing is the most significant tool available to make a change in cover, composition, and health of rangeland. The areas treated using these methods vary in size from one-quarter acre to 1,500 acres for insects or pathogens, to thousands of acres for grazing animals under a variety of grazing prescriptions. Insects and pathogens generally have less of an effect on nontarget vegetation, while the use of grazing animals as biological treatment has a greater potential for affecting nontarget vegetation.

The possible effects of biological control by grazing animals vary by analysis region. Moderate grazing by sheep may improve mountain/plateau grass-

lands as cattle range (Vallentine 1980). Grazing of sagebrush vegetation by cattle and sheep in the spring and early summer can increase the vegetative output of desirable shrubs for winter browse. Heavy fall grazing by sheep on these same ranges improved the range condition faster than no grazing at all (Vallentine 1980). Goats can be important biological control agents for woody plants, especially in desolate, semi-arid sites. Goats have been found to be effective on oaks, mesquite, chamise, and sumac on desert shrublands, southwestern shrub-steppes, and chaparral (Vallentine 1980), increasing the species diversity of these areas. Negative impacts from biological control by grazing animals can be mitigated and positive effects accentuated with proper planning and management of a grazing system.

The impacts of biological treatment by insects and pathogens on vegetation will generally be slight. In most cases, the target plants will remain standing, though they may be weakened or unable to reproduce, thus reducing noticeable and immediate effects. Over time, the composition of the plant community may change, as the native plants regain their competitive edge. Any insects or pathogens used for general vegetation treatment would be carefully tested for host specificity, thus reducing or eliminating possible negative effects on native vegetation.

Prescribed Burning

Prescribed burning (Figures 3-1 and 3-2) is used to manage unwanted plants, especially woody species that compete with herbaceous species for water, nutrients, and space; to remove the excessive litter accumulation in some herbaceous species that may ignite, smolder for a long time, and kill the herbaceous species growing points; to modify species composition; to enhance herbaceous productivity; to manage plant community structure; to improve quantity and quality of wildlife habitat; and to reduce fire hazard from surface fuel buildup.

Figure 3-1. Helicopter igniting a prescribed burn.

Figure 3-2. Crew member monitoring prescribed burn aimed at improving forage and wildlife habitat.

The use of fire affects the productivity of plants and has a significant effect on plant competition. In areas where prescribed burning is not used, plant communities may be affected by increased plant competition. The extent of these impacts depends upon numerous interacting factors that determine the ultimate response of a particular ecological system to fire. These factors include weather conditions before and after a burn; time of the year (whether plants are growing or dormant); physical features of the site; particular species; plant life form (shrub, grass, tree, and so forth), method of reproduction, stage of maturity and vigor; amount of fuel available and its moisture content; severity and intensity of the burn; rate of fire spread; flame length; depth and duration of heat penetration into organic and soil layers; and frequency of fires. Prefire and postfire management also have an effect on the composition and productivity of plant communities.

Fire can have a significant effect on postfire plant productivity. Productivity may significantly decrease during the initial postfire recovery period, then increase after 1 or several years. Productivity may increase after the first growing season. Total productivity may not change significantly, but it can shift among classes of plants on the site, such as from conifers that are killed by a fire to shrubs, grasses, and forbs. Total vegetative productivity may actually decrease but shift from less desirable to more desirable species, as from woody plants to grasses and forbs. Immediate productivity increases are usually more likely if significant amounts of vegetative reproduction or regeneration occur, than if the site must reestablish from seed.

Fire has a significant effect on plant competition by changing the numbers and species of existing plants, altering site conditions, and inducing a situation in which many plants must reestablish on a site. In a postfire situation, established perennial plants that are recovering vegetatively usually have an advantage over plants that are developing from seed, because they can take up water and nutrients from an existing root system while seedings must develop a new root system. Sprouting plants may rapidly develop a crown that can shade out other plants or limit their growth. Natural regeneration of shrubs may severely limit growth of naturally occurring or planted conifers because of competition for light or moisture (Stein 1986). Grass seeded for postfire erosion control in forested areas may overtop conifer seedlings. In chaparral areas they may compete with sprouts and seedlings of native plants

(Barro and Conard 1987). Litter from seeded grasses may also increase the flammability of the site to much higher levels than would occur if only native vegetation recovered on the site (Cohen 1986 as cited in Barro and Conard 1987). A second fire after a short-term interval might kill all seedlings of native species before they have produced much seed. Therefore, numbers and vigor of native plants would be further reduced. Cheatgrass seedlings can grow roots at much cooler soil temperatures than many native perennial grass seedlings and use up soil moisture in the spring before other species get their roots down into the soil profile (Thill et al. 1984).

On sites that are not burned, some species may have a competitive advantage. For example, junipers can take up increasing amounts of soil water in sagebrush/grass communities they have invaded and eventually exclude most other species because of moisture limitations. Grass production tends to decrease as sagebrush cover increases, again because of competition for water. Young stands of conifers that develop in the absence of fire beneath mature overstories of ponderosa pine compete with the mature trees for moisture and nutrients, weakening them and making them susceptible to insects and disease. Depending upon the site, prescribed fire or fire in combination with other treatments is the most efficient and ecologicaly sound way to manage these plant communities.

If burning occurs in close association with heavy use of the plant community by livestock or wildlife, either before or after the burn, plant recovery may be delayed or prevented because heavy prefire use may deplete plant carbohydrate reserves. Heavy postfire use of perennial plants in the first growing season after a fire is likely to cause the most harm, particularly in arid and semi-arid range communities (Trlica 1977). Livestock and wildlife are often attracted to burned areas because of increased palatability, availability, and the earlier spring greenup that often occurs on burned rangelands and grasslands. Depending on the plant community and its production capabilities, some use after the first full growing season may not have a negative effect, and indeed may be desirable, as in tobosagraaa communities. In most cases, however, two full growing seasons of postfire rest are necessary before plants can sustain much utilization (Wright and Bailey 1982). A longer recovery period is necessary if weather has been unfavorable for growth or if establishment of plants from seeds is required to completely revegetate the site. Desert plants required more than 7 years of recovery after moderate defoliation (Cook and Child 1971, as cited in Trlica 1977), and some shrubland sites may require this long a period pf postfire rest if recovery of browse species is desired.

For some plant communities in poor condition or dominated by undesired species, it may be necessary to artificially reseed the area after burning because natural revegetation by desired species is unlikely to occur. Tradeoffs are made in prescribed burning. Short-term undesirable effects on preferred species have to be accepted to obtain the desired results on target species. If undesirable species that respond positively to prescribed fire are present on the site, it may be possible to choose a prescription for burning that will favor other species. In some situations, a better choice may be to avoid burning that site and select another treatment method that will produce optimal desired effects.

The observed responses of plants to burning are dependent upon the above factors and other localized conditions in each of the impact analysis areas. Because these factors determine the outcome of a particular prescribed burn, onsite management decisions can alter fire effects to meet specific goals. In general, prescribed fires are planned with specific goals and conducted under constraints to ensure that the fire is contained, that fire and resource objectives are met, and that long-term site productivity is maintained or enhanced.

A particular plant species may or may not be considered desirable on a treatment site, depending on the specific objective of the treatment. For example, less sagebrush would be desired on a site where the objective was to improve elk summer range than if the objective were to improve sage grouse habitat. The following discussion of fire effects by vegetation analysis region reflects this idea in that it describes the effects of fire on particular species without giving a qualitative judgment of whether a plant is desirable. That determination will be made on a site-specific level according to the individual goals of the management plan. The fire ecology of rangeland is discussed in greater detail in Appendix F.

Sagebrush

The effect of fire on grasses in the sagebrush analysis region depends upon the growth form and how season of burning influences soil moisture and other environmental and prescribed burning conditions. Many of the dominant grass species of the sagebrush analysis region are fairly fire resistant and can produce new shoot growth even after moderate-to-high-severity burns.

When desirable understory plants are present within the sagebrush community, prescribed fire can release these species. Spring or fall fires are most desirable and effective because the soils are moist and cool, and the burning is more selective. Sprouting shrubs such as bitterbrush, mountain snowberry, and gamble oak respond favorably, and perennial grasses are benefited. Burning can be used to increase edge effect and increase plant diversity (Bowns 1990).

Repeated or early summer burning reduces perennial grasses and may allow cheatgrass to invade and maintain populations (Wright and Bailey 1982). Bunchgrasses that contain dense plant material in their bases are more damaged than coarse-stemmed and rhizomatous species (Wright and Bailey 1982). Needle-and-thread grass, Thruber needlegrass, and Idaho fescue are the dominant grasses that are most easily harmed by fire in this analysis region (Tirmenstein 1987a, Tirmenstein 1987b, Bradley 1986c). All of these plants have an accumulation of dense culms at their base that tend to concentrate heat if the fire occurs during a dry period, although Thurber needlegrass has somewhat less density of basal fuel. Large diameter bunches of these three species have all been reported to sustain more damage from fire than smaller diameter bunches. Both needlegrass species have been observed to reproduce from seed after fires. The greated amount of damage to these plants occurs either if they are burned when actively growing or have green tissue; when they are more sensitive to fire temperatures; or when basal material is very dry, can ignite and smolder, and can concentrate heat. Prescribed fires with an objective of enhancing or maintaining grasses would not be scheduled when key species are more sensitive to fire. Bunchgrass plants that survive a fire can return to preburn coverage and production within 2 years (West and Hassan 1985), but the recovery time may be shorter or much longer, depending on the amount of damage sustained by the plant, its recovery potential, site productivity, postfire weather, and postfire animal use.

Big sagebrush and other nonsprouting shrubs are almost always killed by fires and may take decades to recover preburn status in the community (Harniss and Murray 1973). The rate of reestablishment depends on the size of the area burned, postfire grazing management practices, and the subspecies of sagebrush. For example, silver sagebrush plants resprout vigorously after spring burning but may suffer extensive mortality after fall burning (White and Cusive 1983). Big sagebrush is a valuable forage plant on critical deer winter range and should be protected from fire in these areas (Vallentine 1980). Examples of desirable forage shrubs in the sagebrush region that are damaged by fire are curlleaf mountain mahogany and cliffrose. Target sprouting shrubs, such as greasewood, may be top-killed by fire but will resprout as soon as conditions are favorable (Blaisdell 1953, Britton and Ralphs 1978). Bitterbrush is a species of special interest because it has valuable forage and browse qualities. It reproduces from seed and by resprouting. Because bitterbrush plants die of old age, fire seems to be necessary for maintenance of the species, even though mortality of plants during any fire may be high. Mortality is minimized by burning when soils are moist, either in the spring or late in the fall after plants have become dormant and rain has fallen. Mortality is highest when fuel consumption is high.

Perennial forbs generally respond better to burning than do bunchgrasses (Britton and Ralphs 1978), probably because their growing points are protected by soil layers to a greater extent than are grasses. Fall burning does not harm most forbs because many of them are dry and disintegrated by that time (Wright 1985). However, forbs that are still green are still very susceptible to fall fires (Wright 1985), as are forbs such as some of the Antennaria spp. and Phlox spp. (Pechanec and Stewart 1944) that have growth points at the surface. Perennial forbs can recover from summer burning in 1 year (West and Hassan 1985). Balsamroot has been observed to respond very well to even a summer wildfire after drought conditions, because it sprouts each year from well below the soil surface (Miller 1987).

Desert Shrub

Vegetation manipulation treatments are not often practiced on salt desert shrub, blackbrush, or Mohave and Sonoran Desert shrublands (Jordan 1981), and those attempted have had limited success. Fire frequency in these vegetation types is historically low. However, wildfire incidence has increased in some of these areas because of the presence of exotic annual grasses (Lotan and Lyon 1981, Patten and Cave 1984). Many areas of the Mohave and Sonoran Deserts are too dry in most years to produce enough fuel to carry a fire. Fires occur in the Sonoran Desert northeast of Phoenix only after 2 years of above average precipitation that encourages growth of annuals (Rogers and Vint 1987). Creosotebush communities rarely burn because of low herbaceous cover (Sampson and Jesperson 1963, as cited in Korthuis 1988b).

Many shrubs, trees, and cacti of the hot desert can be severely affected by burning because they are not adapted to fire. Paloverde, burroweed, bursage, broom snakeweed, ocotillo, and creosotebush are examples of desert species that can suffer high mortality rates from burning (Wright and Bailey 1982), although higher mortality rates seem associated with fires that occur under more extreme burning conditions. Creosotebush susceptibility to fire is apparently highest in June, and it has been reported to sprout after fires during other times of the year. Large numbers of triangleleaf bursage seedlings have been reported after fires in Arizona (Rogers and Steele 1980, as cited in Korthuis 1988a), and broom snakeweed can rapidly reestablish from light, wind-dispersed seed after a fire (Young 1983, as cited in Tirmenstein 1987c).

The following species occur in both Mohave desert and cold desert shrub types. Shadscale, fourwing saltbush (Wright 1980), black greasewood

(Young 1983, as cited in Tirmenstein 1987d), and winterfat (Dwyer and Pieper 1967) have been reported to resprout vigorously after a fire, although August and September wildfire in southwest Idaho killed 95 to 100 percent of winterfat plants (Pellant and Reichert, as cited in Holifield 1987a). These southwest Idaho shrub communities may be somewhat atypical of winterfat communities because they are so far north in their distribution. Cool-season grasses predominate, summer precipitation is rare, and grasses are usually dormant for long periods of the summer, and are thus flammable, compared to warm-season dominated communities to the south where greenup is maintained or occurs intermittently all summer in response to showers (M. Pellant, pers. comm. 1989). Winterfat is reported to have good tolerance for fire when dormant (Wasser 1982, as cited in Holifield 1987a). Fourwing saltbrush has also been reestablished successfully from seed after a fire in central Utah (Clary and Tiedemann 1984, as cited in Tirmenstein 1986a). Spiny hopsage, a resident of both hot and cold deserts, generally resprouts after being burned and is least susceptible to fire during summer dormancy (Rickard and McShane 1984, as cited in Holifield 1987c).

Southwestern Shrubsteppe

The most common use of fire in southwestern shrubsteppe areas is to control woody species, such as snakeweed, burroweed, creosotebush, and especially velvet mesquite. While high kills of velvet mesquite are rare (Wright and Bailey 1982), the species is moderately affected by fire, depending upon plant size and fuel load near the plant (Cable 1965). Most small mesquite plants can be top-killed; resprouting occurs and only periodic burning can maintain a grassland aspect (Martin 1983). Low shrubs, such as false mesquite, are only moderately affected by fire and can increase after burning (Reynolds and Bohning 1956). Ocotillo, Wheeler sotol, larchleaf goldenrod, and paloverde can be severely damaged by fire (Wright and Bailey 1982). Additionally, many cactus species are susceptible to fire damage (Cable 1965, Wright and Bailey 1982, Martin 1983).

In general, perennial grasses are mildly to severely harmed by fires during dry years but quickly recover during wet years (Wright and Bailey 1982). Burning may stimulate seedling emergence in some species (Ruyle et al. 1988). Fire has the greatest benefit to tobosa, big sacaton, and alkali sacaton ranges. Of the dormant perennial grasses, black grama is most seriously affected by burning because it is a stoloniferous grass with growing points right at or near the surface. Postfire recovery is slow and is hindered by postfire drought (Canfield 1939, Reynolds and Bohning 1956). If a postfire drought period is confounded by moderate grazing, black grama may never achieve preburn status in a community (Canfield 1939). In areas where annual precipitation is higher, black grama is not excessively damaged even by hot summer fires (Wright and Bailey 1982).

Chaparral-Mountain Shrub

The ecological effects of fire in chaparral communities are complex because of the diversity of this community type. Chaparral shrub species are highly flammable because of their high surface area-to-volume ratio, high fuel bed porosity, and high leaf oil content (Lotan and Lyon 1981). They may sprout, reproduce from seed, or both; but without fire, nonsprouting shrubs will be greatly reduced in the community (Keeley and Zedler 1978). Chaparral stands grow rapidly after fire and take about 25 years to mature and senesce (Lotan and Lyon 1981).

Fire can be a good tool for thinning dense chaparral and encouraging palatable nonsprouting species. Nonsprouting species, like point leaf manzanita, cliffrose, and desert ceanothus, maintain themselves by prolific seedling growth following burns (Keely and Zedler 1978). Scrub oak, leather oak, and mountain mahogany are sprouting species that are enhanced by burning (Keeley and Zedler 1978, Wright and Bailey 1982).

Shrub live oak (turbinella oak) is the dominant species in many stands of Arizona chaparral, resprouts vigorously from root crowns after most fires (Davis and Pase 1977, as cited in Tirmenstein 1988a), and can also sprout from adventitious buds on its roots. Fuels are frequently limited in shrub live oak communities, and it is difficult to make a fire carry through a stand (Pond and Cable, as cited in Tiemenstein 1988). Scrub oak, western and hairy mountain mahogany, and leather oak are sprouting species that are enhanced by burning (Keeley and Zedler 1978, Wright and Bailey 1982).

Although grasses and forbs are not abundant in chaparral stands, annual forbs and grasses are enhanced the first year after a fire (Wright and Bailey 1982). Perennial forbs, such as brodea and lilies, are also common after burns (Wright and Bailey 1982).

The dominant plant of the mountain shrub community is Gambel oak, which can resprout vigorously after fire, both from lignotubers and from rhizomes. However, wildfire can greatly decrease vigor and growth of postfire sprouts where considerable amounts of soil heating occur. In some areas where fires have burned with less severity, indicated by the presence of residual stem bases, shrubs sprout vigorously, reaching heights of 6 feet in 6 years (T. Zimmerman, pers. comm. 1989).

A major objective for burning mountain-shrub communities is to resize them, making browse more palatable for wildlife, and increasing accessibility by

reducing shrub thickets. Wright and Bailey (1982) cite several authors who feel that oakbrush communities should not be burned because herbage yield and species composition are not improved unless they are artificially seeded. Sites burned in west central Colorado not only have vigorous resprouts after August prescribed fires, but also have shown excellent recovery of elk sedge (T. Zimmerman, pers. comm. 1989). While some of the species of mountain shrub communities might be harmed by fires that occur under extremely dry conditions, most prescribed fires would be designed to enhance sprouting or establishment of new individuals from seed.

Pinyon-Juniper

Mature stands of pinyon and juniper are frequently too open or contain insufficient herbaceous fuel to carry a fire (Lotan and Lyon 1981). However burning can easily kill pinyon species and nonsprouting juniper, especially trees less than 4 feet tall (Dwyer and Pieper 1967). Larger trees require heavy amounts of fire fuel within their canopy coverage to crownkilled (Jameson 1962). Where understories include sagebrush, large pinyon and juniper trees can be killed by fire (Bruner and Klebenow 1978).

Postfire recovery of five of the six species of pinyon and juniper after fire is dependent upon seed reproduction, and thus the rate of reinvasion depends on distance to seed source, the size of the burned area, and the presence of dispersal agents. Pinyons and junipers do not produce seed until they are about 20 to 30 years old.

Older trees generally become more fire resistant as bark thickens and the crown becomes more open, and may be able to survive low intensity fires. It is difficult to kill trees in fairly closed stands of pinyon-juniper because there is little live or dead fuel on the surface, and a prescribed fire will not carry unless there are extremely high winds, a situation in which risk of fire escape is high. A normal treatment in pinyon-juniper stands is to chain or manually cut the trees, leave the slash scattered, wait several years for grasses and shrubs to recover, and then burn the site. This removes most of the dead fuel, greatly reduces the fire hazard, and kills any residual or newly germinated pinyon and juniper trees. If a site is mechanically or manually treated only, it will probably have enhanced forage and browse production for about 20 years. Prescribed burning of the site about 3 to 5 years after treatment, once an understory has established, will maintain the productive character of the site for about 50 years (West 1979, as cited in Tiemenstein 1986b, Wright et al. 1979, as cited in McMurray 1986b). Understory recovery in pinyon stands is very closely related to the type and number of residual plants on the site (McMurray 1986b, McMurray 1986c). If tree dominance has seriously depleted remnant shrub, forb, and grass plants, and the soil seed reserve, the site will have to be artificially reseeded after fire (McMurray 1986b), particularly in areas where invasion by annual grasses is possible. If high rates of forage utilization (which reduce fuels) and fire exclusion continue to be practiced on sites invaded by pinyon juniper, tree density will continue to increase, and pinyon and juniper will continue to expand onto shrub- and grass-dominated sites (Burkhardt and Tisdale 1976). An active management program that includes prescribed fire will be necessary to reduce the amount of tree encroachment and maintain the character and productivity of the original plant community.

Sprouting shrubs, such as western serviceberry, true mountain mahogany, chokecherry, winterfat, fourwing saltbush, rabbitbrush, and horsebrush, may regrow quickly postburn (Wright et al. 1979), while shrubs such as bitterbrush, broom snakeweed, and curlleaf mountain mahogany may or may not resprout, depending upon fire and postfire conditions. Cliffrose may be completely eliminated. Alligator and redberry juniper are sprouting junipers that can be killed by fire (Wright and Bailey 1982).

Burning grass results in responses similar to those seen in sagebrush-grass communities. Large bunchgrasses are more affected than small grasses with coarse stems, and rhizomatous species tolerate fire well (Everett 1987a). Perennial forbs are usually only slightly damaged by fire, except those mat-forming species such as Antennaria spp. (Wright and Bailey 1982, Everett 1987a). Cheatgrass may increase after burning in these communities (Wright and Bailey 1982) if it is present in the stand or in the area before burning, if few residual native bunchgrass plants remain on the site, or if good postfire grazing management practices are not followed. If bunchgrass communities are in good condition when the site is treated, cheatgrass may persist for only a few years. On site sites, cheatgrass never appears (Klebenow et al. 1976).

Plains Grassland

Prairie shortgrasses are generally harmed by fires during dry years. Buffalograss, annual bluegrass, and western wheatgrass may take 3 or more years to recover (Wright and Bailey 1982). During years with above normal spring precipitation, these grass species can tolerate fire with no herbage yield reduction following the first growing season (Wright 1974a). Red threeawn, sand dropseed, Muhlenbergia spp., wolftail, and galleta are all harmed by fire during dry years but tolerate it better during wet years (Dwyer and Pieper 1967, Wright 1974a). Burning usually increases production of sand bluestem and switchgrass but decreases little blues-

tem production where these grasses occur (Wright and Bailey 1982).

Important mixed prairie grasses include tobosagrass (effects described in southwestern shrub-steppe), green needlegrass, sideoats grama, prairie sandreed (reedgrass), and sand dropseed. Green needlegrass is similar to other needlegrasses in that it is fairly sensitive to fire, although the effect can be moderated by burning conditions and site characteristics. Green needlegrass is more negatively affected if a fire occurs when soils are dry or where plants are large in diameter and have more fuel (Wright and Klemmedson 1965, as cited in Tirmenstein 1987e). Sideoats grama is most seriously damaged by fire during very dry years and is tolerant of fire during exceptionally wet years (Wright and Bailey 1980), or when it is dormant (Wasser 1982, as cited in Tirmenstein 1987f). Prairie sandreed is a strongly rhizomatous grass that is fire tolerant when dormant and revegetates a burned area with new shoots from rhizomes. It has responded more favorably to spring fires than to fall fires, which reduced it significantly (Lyon and Stickney 1976, as cited in Uchytil 1988). Vine mesquite and Arizona cottontop do well after fire during periods of good soil moisture (Box et al. 1967, Wink and Wright 1973).

The tolerance of forbs to burning depends upon the timing of the fire relative to active plant growth (Wright and Bailey 1982). Those forbs that start growing after the burning season are least affected, because they have the entire growing season to recover from any injury that the fire may have caused.

Important species of shrubs not previously mentioned are honey mesquite, sand shinnery oak, cholla, and several species of sumac. Honey mesquite, with its exceptional ability to resprout, is almost impossible to kill by burning after it is about 1 foot tall, and even the seedlings are fairly fire tolerant (Wright et al. 1976, as cited in Wright and Bailey 1982). Sand shinnery oak sprouts prolifically after fire, and density of stems has been reported to increase 15 percent after burning (McIlvain and Armstrong 1966, as cited in Wright and Bailey 1982). Young cholla plants can be killed by fire, but those taller than 1 foot were hardly damaged by burning in New Mexico, probably because the short grasses could not generate long enough flames to damage the upper part of the plants (Dwyer and Pieper 1967, Heirman and Wright 1973, both as cited in Wright and Bailey 1982).

Mountain/Plateau Grassland

The effect of fire upon many of the dominant shrubs and grasses in the mountain/plateau grasslands analysis region was discussed in some detail in the section on the sagebrush analysis region. Species covered in that section include big sagebrush, rabbitbrush, horsebrush, western wheatgrass, bluebunch wheatgrass, Idaho fescue, and needle-and-thread areas. The literature does not indicate any significant differences in fire effects for these species that are characteristically related to analysis region, so the information will not be repeated here.

Other important shrubs of the mountain/plateau grasslands include silver sagebrush, fringed sagebrush, shrubby cinquefoil, and prickly pear cactus. Plains and mountain silver sagebrush are an exception to most sagebrush species because they are moderately resistant to fire, being able to produce sprouts from roots and rhizomes. Sprouting decreases as fire severity and heat penetration into the soil increases, particularly after fall fires when the soil is dry. Silver sagebrush rapidly regains preburn cover after spring fires, although coverage is decreased significantly after many fall fires (McMurray 1987a, McMurray 1987b). Fringed sagebrush is reported to be a weak sprouter after fire (Wright et al. 1979, as cited in Tirmenstein 1986c), although response to fire is variable. The most beneficial effects were reported after early spring fires (Anderson and Bailey 1980, as cited in Tirmenstein 1986c), and mortality has been reported after both spring and fall fires. Fringed sagebrush is a prolific seed producer, and seed may remain viable for many years and germinate when conditions are favorable. Postfire reproduction from soil-stored seed does occur. A range of responses to fire have been reported for shrubby cinquefoil. The plant has a wide-ranging distribution and likely ecotypic variability that affects its ability to sprout. Whether a particular plant sprouts after a fire apparently relates to site characteristics, season of burn, fire intensity, and burn severity. Cinquefoil has a been observed to produce sprouts from buds on its root crown, rhizomes, and prostrate stems that survived the fire. Survival is most often reported after spring fires. Shrubby cinquefoil can also reestablish through an abundance of wind-dispersed seed (Tirmenstein 1987g). The effect of fire upon prickly pear varies with plant height, stem moisture content, and the amount of associated fuel, because the plant itself will not burn (Humphrey 1974, as cited in Holifield 1987e). It can resprout from any surviving root crowns and by adventitious rooting of remaining pad (Holifield 1987e). Postfire death of prickly pear is often caused by postfire damage by insects, rodents, rabbits, and livestock, or by dehydration (Holifield 1987e).

Important native grasses of the mountain/plateau grasslands that have not been previously discussed include rough fescue, oatgrasses, and mountain brome. Rough fescue is a large-diameter, coarse-stemmed bunchgrass that seems well adapted to periodic burning. It is susceptible to damage from fires during hot dry weather, although it has bene-

fited from spring sand fall prescribed fires. In areas where it has not been grazed or burned for many years, accumulations of litter may ignite and smolder for a long time after a flaming front has passed, causing significant basal bud mortality. Fescue is also particularly sensitive to burning during the activate growing season (Sinton 1980 in McMurray 1987e). Antos et al. (1983, as cited in McMurray 1987e) suggest that the most beneficial fire frequencies for rough fescue are about every 5 to 10 years. Little information is available about the response of oatgrasses to fire, although other oatgrass species in the Pacific Northwest are reported to be moderately resistant to fire. One-spike oatgrass, a densely tufted to matted perennial bunchgrass, was reported to increase in basal cover after two spring prescribed fires in southwest Montana (Nimir and Payne 1978). Mountain brome, a short-lived perennial bunchgrass with shallow roots regained 76 percent of its preburn cover within 12 weeks, compared to a control, after one of those same spring fires studied by Nimir and Payne.

The native grass species of the Palouse grasslands of eastern Washington and Oregon and northern Idaho include bluebunch wheatgrass, Idaho fescue, and Sandberg bluegrass. They have been replaced in many locations by introduced exotics, including Kentucky bluegrass, cheatgrass, medusahead, and other bromes. Severe summer fires can kill bluebunch wheatgrass and Idaho fescue in this area, although cover of these plants was not affected by cool fires (Daubenmire 1970). Cheatgrass will continue to expand at the expense of native perennials because it is so widely established and so highly flammable. It will burn when native perennials are still actively growing and much more sensitive to fire heating. Medusahead is a highly flammable exotic annual that is capable of replacing cheatgrass in many areas, particularly where soils have high clay content. It can be somewhat controlled with fire if it is burned after it is cured but before seeds are dispersed from the stalk. Many of the seeds are destroyed, and fewer seedlings will germinate. Medusahead will then offer less competition to the seedlings of seeded grasses that are usually sown on these sites after burning (Ahlenslager 1987b).

Coniferous/Deciduous Forests

Prescribed burning can be an effective management tool in forested vegetative communities in the West. Fire is used to reduce surface fuels on clearcuts as well as in the understories of fire resistant trees; to remove understory reproduction in ponderosa pine, Douglas-fir, and western larch forests, which provide a fuel ladder to the overstory; to thin overstocked stands of trees; to prune lower branches from trees; to create seedbed; to reduce vegetative competition with naturally regenerated or planted conifers; to enhance forage values; to maintain and improve browse quality and quantity; and to rejuvenate old stands of deciduous trees.

Understory burning at planned intervals is the best way to manage sites with ponderosa pine, Douglas fir, and western larch the dominant tree species. If all fires are excluded from these forests types, which historically had high frequencies of understory fire, the eventual result can be the weakening of the stand, an increase in activity of bark beetles, and an increase in the proportion of dead trees. Fuels and/or bug-killed trees lead to stand-destroying fires. Many acres in the West have had fire excluded for 50 to 75 years, and some of the fires in recent years are likely a result of the accumulation of fuels and insect activity.

Slash from thinning and selective logging can be burned to reduce fire hazard without harming the residual trees in these communities. Ponderosa pine is generally not clearcut, but clearcuts in Douglas-fir and western larch are often burned to manage the fuels, prepare seedbed and planting spots, and manage competing plants. Without fire, ponderosa pine and Douglas-fir sometimes invade grasslands, and prescribed fire can be easily used to eliminate these trees when they are young.

Most conifers produce only by seed after a fire, and prescribed fire can produce favorable conditions for nearly all conifers. Burning ponderosa pine forests will increase grasses and top-kill shrubs, such as chokecherry, western serviceberry, and bitterbrush, which will sprout the next year. In general, fire is beneficial to grasses and forbs in ponderosa pine associations but not where shrub understories dominate (Wright and Bailey 1982). Burning of Douglas-fir forests increases shrubs such as snowbush, ceanothus, western serviceberry, common snowberry, and sticky currant. In some Douglas-fir areas, ponderosa pine and quaking aspen may become fire climax species. Although easily killed by surface fires, quaking aspens quickly sprout from roots, making the tree a superior competitor in many Douglas-fir and spruce-fir forests.

The lack of understory herbaceous fuel caused by livestock grazing precludes the occurrence of fire in most aspen stands (Jones and DeByle 1985). Without fire, conifers invade many aspen stands, gradually eliminating the aspen, because aspen sucker replacement is often insufficient to replace overstory aspen mortality (Schier 1975). Aspen communities on sites not suited for conifer establishment may eventually be replaced by grasses and shrubs (Schier 1975). Suckering is prevented by the presence of mature trees as the trees and roots gradually deteriorate. Loss of aspen stands because of this phenomena has been observed in several Western States. A fire that occurs in an aspen stand that is still producing a few suckers, or in a mixed aspen-

conifer stand is likely to result in the rejuvenation of the aspen stand. The amount of postfire suckering is enhanced by warmer soil temperatures, which usually occur as a result of the blackened soil surface and reduced thickness of the litter and organic layer (Jones and DeByle 1985). As is true for rangeland sites, an aspen site must be rested from grazing until the community recovers to some degree (Brown and Simmerman 1986). Wildlife use can be regulated to some extent if a large enough burned area is selected, or if several areas in the same general vicinity are burned, thus dispersing use over a greater acreage.

The understories of ponderosa pine, Douglas fir, and western larch communities are all adapted to fire. Some later successional species that may have established because of fire exclusion might not be favored, but the natural shrub, forb, and grass associates of these species would recover by sprouting or from seed stored in the forest soil organic layer (duff) after fire. The exact response varies by fire prescription, season, moisture condition, and plant species, a topic that would be covered in a site-specific environmental assessment.

Slash burning potentially could do more harm to a site than prescribed underburning because of the presence of large amounts of slash on the soil surface. An objective for slashburning may be to kill some of the understory species so that less competition is present for trees that might be planted. Specific ranges of moisture content of large diameter fuels, duff, and soil can be selected for the fire prescription that will have the desired effect on understory vegetation, with consideration given to the effects of burning on the soil. One effect of this treatment, which is perhaps more closely associated with the removal of the forest overstory than of the burning itself, is that plants that require sunlight will do better after the treatment than those that require shade. This change in dominant species, or species present, would persist until the forest overstory again develops to the point where it provides a good cover of shade.

Chemical Methods

Annual plants are generally more sensitive than perennial plants to chemical treatments because they have limited food storage organs and annual plant populations are greatly reduced if plants are killed before producing seed. Perennials are most sensitive when exposed to herbicides during periods of active growth. Exposure to herbicides during active growth and before plants become reproductive also will have the greatest negative effect on populations of many annuals. The ability of annual or perennial plants to maintain viable seeds in the soil for several years reduces their susceptibility to herbicides. Control of some woody plants on some sites may open the community to dominance by annuals (Evans and Young 1985).

Susceptibility of perennial plants to herbicides depends largely on their ability to resprout after aerial shoots are damaged (Table 3-3). Plants that have the ability to resprout after aerial shoot damage are generally least sensitive to herbicides. These plants are damaged most when exposed to herbicides when translocation to meristematic areas and to roots is active (Sosebee 1983). This generally occurs only when soil temperatures are adequate for root activity and soil water is available. These plants are generally less susceptible to foliar-applied herbicides with limited exposure periods, such as 2,4-D, than to soil-active herbicides, such as tebuthiuron, that persist in the soil long enough to be taken up when optimum translocation conditions occur.

Differences in active growth periods and phenology of nontarget and target species that correspond to differences in sensitivity to herbicides can be used to minimize damage to nontarget species. For example, damage to bitterbrush while spraying 2,4-D to control sagebrush can be minimized if spraying is done between the time when new bitterbrush leaves appear and when twig elongation and flowering occurs (Hyder and Sneva 1962).

The greater the similarity of target and nontarget species in a given plant community, the greater the damage to nontarget species during herbicide treatments. Because many broadleaf herbaceous and woody plants are considered target species on many rangelands, herbicides such as 2,4-D and dicamba, which selectively control broadleaf plants, are often used. These herbicides damage grass and grass-like plants very little but may damage nontarget broadleaf forbs and shrubs (Blaisdell et al. 1982). Use of dicamba at a rate greater than 4 pounds acid equivalent/acre (a.e./acre) can damage certain grass species. On the other hand, use of dalapon to control weedy grasses will have little effect on associated broadleaf plants but may damage nontarget perennial grasses.

Response of nontarget species to broad-spectrum herbicides, such as glyphosate and tebuthiuron, may be highly dependent on the rate of application. Damage to nontarget species is minimized if they are tolerant of these herbicides applied at rates sufficient to kill target species. For example, picloram applied at rates sufficient to kill rabbitbrush may initially reduce growth of associated perennial grasses, but grass production may eventually increase as shrubs die and grasses recover (Tueller and Evans 1969).

Plants may vary greatly in their sensitivity to different herbicides (Sosebee 1983). Effectiveness of herbicides may vary with different climatic and soil

Table 3-3

General Description of Vegetation Susceptibility to Herbicides

Herbicide	Selectivity and Vegetation Susceptibility
Amitrole	Use is no longer proposed. BLM has reexamined the risk assessment and examined additional data. BLM has determined that amitrole is no longer considered for proposed use in this document. Amitrole will be deleted in the Record of Decision.
Atrazine	Selective. Broadleaf and grassy weeds are susceptible.
Bromacil	Nonselective. Annual and perennial grasses, broadleaf weeds, and some woody species are susceptible.
Chlorsulfuron	Selective. Most broadleaf weeds and some annual grassy weeds are susceptible.
Clopyralid	Selective. Many broadleaf annual and perennial weeds and woody plants are susceptible.
2,4-D	Selective. Broadleaf weeds and dicots are susceptible.
Dalapon	Since drafting this document, producers are no longer manufacturing formulations registered for proposed use. Therefore, dalapon is no longer considered for use.
Dicamba	Selective. Annual and perennial broadleaf weeds, brush, and vines are susceptible.
Diuron	Selective at low rates, nonselective at higher rates. At low rates, germinating broadleaf and grass weeds are susceptible. At higher rates, most plants are susceptible.
Glyphosate	Nonselective. Most plants are susceptible.
Hexazinone	Nonselective. Annual and biennial weeds, woody vines, and most perennial weeds and grasses are susceptible.
Imazapyr	Nonselective. Annual and perennial weeds, deciduous trees, vines, and brambles are susceptible.
Melfluidide	Nonselective. Suppresses vegetative and seedhead growth in many species.
Metsulfuron Methyl	Nonselective. Broadleaf weeds and annual grassy weeds are susceptible.
Picloram	Nonselective. Most annual and perennial broadleaf weeds and woody plants are susceptible.
Simazine	Selective. Broadleaf and grass weeds are susceptible.
Sulfometuron Methyl	Nonselective. Annual and perennial grasses and broadleaf weeds are susceptible.
Tebuthiuron	Nonselective. Most plants are susceptible.
Triclopyr	Selective. Woody plants, broadleaf weeds, and root-sprouting species are susceptible.

Source: Weed Science Society 1979.

conditions. Soil-applied herbicides are less effective on fine-textured soils relative to coarse-textured soils, because herbicide molecules may be adsorbed to clay colloids. Response of nontarget plant species to herbicides depends not only on their susceptibility to the herbicide directly, but also on their response to a decrease of target plant species in the community. The herbicides proposed for prescribed burning pretreatment, sagebrush control, and saltcedar eradication are selective, yielding no adverse effects on grasses. Proposed treatments to saltcedar are limited to hand treatment of cut stumps with picloram or triclopyr herbicides applied by paint brush. Picloram used in saltcedar eradication programs may kill or damage interspersed nontarget trees through translocation from saltcedar roots to

soil to other roots. Vegetation removal needs (for example, rights-of-way, pipelines, drilling pads, and administrative sites) would be accomplished with broad spectrum, nonselective herbicides that would affect most perennial plants, annuals, and biennial grasses, sedges, rushes, and broadleaf plants. Maximum weed control measures may require either selective or nonselective chemicals, depending upon individual situations.

Sagebrush

In the sagebrush analysis region, herbicides are used to control woody plants, such as species of sagebrush and rabbitbrush, as well as herbaceous weeds, such as cheatgrass and medusahead, (Evans et al. 1979). This discussion will consider effects of herbicides commonly used on grasses, shrubs, and forbs.

Herbicides have been most commonly applied to sagebrush rangelands to control species of sagebrush and rabbitbrush and to increase production of perennial grasses (Blaisdell et al. 1982). When desirable understory plants are present within the sagebrush community, prescribed fire can release these species. Chemicals can be used for the initial treatment or to maintain the stand once sagebrush density increases or it invades the stand. Because it selectively injures broadleaf plants, but not grass or grass-like plants, 2,4-D has most frequently been used to reduce woody species and increase production of native grass stands and to renovate seeded grass ranges (Table 3-4). When 2,4-D is applied in the spring when temperatures and soil water are conducive to active growth, sagebrush mortality is high and grass production is increased (Alley 1956, Fisser 1968, Tabler 1968, Sturges 1973, and Evans et al. 1979).

Table 3-4

Mortality of Forbs on Areas Sprayed With 2,4-D to Control Big Sagebrush

Species	Mortality
Achillea millefolium	Unharmed
Agastache urticifolia	Light
Agoseris ssp.	Moderate
Antennaria microphylla	Light
Aplopappus sp.	Unharmed
Arenaria congesta	Unharmed
Arnica fulgens	Light
Aster foliaceus	Unharmed
Aster scopulorum	Moderate
Astragalus convallarius	Unharmed
Astragalus miser praeteritus	Unharmed
Astragalus salinus	Unharmed
Astragalus stenophyllus	Heavy
Balsamorhiza sagittata	Heavy
Calochortus macrocarpus	Unharmed
Castilleja spp.	Heavy
Comandra umbellata	Light
Crepis acuminata	Unharmed
Delphinium depauperatum	Unharmed
Delphinium glaucescens	Unharmed
Erigeron corymbosus	Light
Eriogonum heracleoides	Light
Eriogonum ovalifolium	Unharmed
Galium boreale	Unharmed
Geum triflorum	Heavy
Geranium viscossissimum	Unharmed
Helianthella uniflora	Heavy
Linum lewisii	Unharmed
Lithospermum ruderale	Moderate
Lupinus caudatus	Heavy
Lupinus laxiflorus	Heavy
Lupinus leucophyllus	Moderate
Lupinus sericeus	Heavy
Mertensia oblongifolia	Heavy
Opuntia polyacantha	Unharmed
Penstemon radicosus	Light
Penstemon spp.	Heavy
Perideridia gairdneri	Unharmed
Phlox canescens	Light
Potentilla gracilis	Heavy
Potentilla spp.	Heavy
Rumex sp.	Unharmed
Senecio integerriumus	Light
Solidago sp.	Unharmed
Trifolium macrocephalum	Heavy
Viola spp.	Unharmed
Zigadenus paniculatus	Heavy

Note: Ratings: unharmed; light, 1 to 33 percent kill; moderate, 34 to 66 percent kill; heavy, 67 to 100 percent kill.

Source: Blaisdell et al. 1982

If understory grasses are lacking, if site potential is low, and if shrub mortality is limited, grass production response to 2,4-D is also limited but is not decreased by spraying. Ineffective control of sagebrush and rabbitbrush usually results in redominance by these species (Johnson and Payne 1968). Where perennial grasses are lacking, controlling sagebrush with 2,4-D and revegetating with adapted grasses greatly increase grass production (Evans et al. 1986). Sites dominated by low sagebrush species have lower potential for grass production after sagebrush control than sites dominated by big sagebrush

(Evans et al. 1979). This productive potential may be too low to justify treatment in many cases (Blaisdell et al. 1982). Even though 2,4-D may injure grass seedlings the first year it is applied (Baker 1958, Klomp and Hull 1968a), this is generally not a problem. Established grasses are tolerant of 2,4-D and should produce increased seed crops for seedling establishment in subsequent years when 2,4-D is no longer present in the environment.

In contrast to perennial grasses, broadleaf shrubs and forbs may be sensitive to 2,4-D atrates applied to kill sagebrush (up to 3 lb a.e./acre). Certain important forage species of forbs, such as arrowleaf balsamroot and milkvetch, are damaged by 2,4-D, while others, such as hawksbeard and geranium, are not. Treatment of sagebrush communities that have high forb density could greatly reduce their production and change the community's relative composition. Blaisdell et al. (1982) emphasize the importance of carefully considering species composition of mixed sagebrush communities before treatment with 2,4-D. Although desirable grasses would be increased, some desirable forbs and shrubs may be reduced.

Picloram (0.5 lb a.e./acre) is often mixed with 2,4-D to increase control of rabbitbrush while controlling sagebrush (Evans et al. 1979).

Picloram may be active in the soil for a few years after application and is potentially more damaging to perennial grasses than 2,4-D alone. Picloram (0.25 to 0.5 lb a.e./acre) decreased production of wheatgrass the first 2 years after its application, but control of sagebrush and rabbitbrush and grass recovery resulted in increased grass production after that time (Tueller and Evans 1969). Picloram (0.5 and 1.5 lb a.e./acre) decreased stands of smooth brome but not intermediate wheatgrass (McCarty 1979). In that study, application rates of picloram (0.25 to 1 lb a.e./acre) recommended to control musk thistle did not reduce nutritional quality of these grasses. Most perennial grasses are more tolerant of picloram than many shrubs and forbs (Vallentine 1980). Application of picloram to control rabbitbrush and forbs in the sagebrush analysis region should be expected to decrease production of shrubs and desired forbs. Picloram may initially decrease production of grasses, but grass production should recover as picloram dissipates.

Tebuthiuron, a broad-spectrum herbicide, has a long period of activity in the soil and may be more effective than 2,4-D in controlling sagebrush. However, tebuthiuron may damage grasses and other desirable plants. In Oregon, tebuthiuron application rates (1.8 lb a.e./acre) sufficient to control sagebrush (more than 90 percent mortality) decreased production of perennial grasses 2 years after application (Britton and Sneva 1983a). Tebuthiuron (1 lb a.e./acre) caused chloroses but did not reduce cover of perennial grasses, such as western wheatgrass, june grass, and needlegrasses, in Wyoming (Whitson and Alley 1984). In that study, blue grama, cheatgrass, and prickly pear were tolerant of tebuthiuron at rates of up to 1 lb a.e./acre. On sagebrush and horsebrush sites in Idaho, grass production increased and stayed the same, respectively, after tebuthiuron (0.5 to 1 lb a.e./acre) application (Murray 1988). Initial decreases in perennial grass production should probably be expected after most tebuthiuron applications. Application of high rates of tebuthiuron (1 lb a.e./acre) may decrease perennial grasses and allow annual grasses, as well as rabbitbrush, which is tolerant of tebuthiuron, to increase (Clary et al. 1985).

Tebuthiuron may damage and reduce production of desirable and undesirable shrubs associated with sagebrush. Woody, succulent, and herbaceous species vary in their sensitivity to tebuthiuron; and tebuthiuron is less effective on clayey than on sandy soils because of its soil adsorptivity. Because of this, additional extensive testing of tebuthiuron is necessary to determine the sensitivity of different species on different sites and more accurately determine vegetation responses to this herbicide. In general, it should be expected that sagebrush would be more damaged than many associated shrubs and grasses at moderate tebuthiuron application rates of 0.5 to 1 lb a.e./acre.

Atrazine is the most often recommended herbicide for chemical fallow of cheatgrass-infested rangelands before revegetation with perennial wheatgrasses (Evans et al. 1969a). Although perennial grass seedlings are sensitive to atrazine (McCarty 1979), the fallow technique allows control of annual grasses, conservation of soil nitrogen and water, and loss of atrazine activity during the fallow year before seeded wheatgrasses emerge. Most broadleaf plants and grasses are sensitive to atrazine. However, injury to these plants is not usually a concern because atrazine treatment of cheatgrass rangelands is usually followed by revegetation with desired species.

Amitrole, bromacil, dalapon, dicamba, and simazine also have been evaluated for cheatgrass control (Canode et al. 1962, Evans et al. 1969b). Although wheatgrass seedlings are tolerant of dicamba (Klomp and Hull 1968b) and dalapon is more injurious to grasses than herbs, most of these herbicides are injurious to perennial grasses and broadleaf plants. Their application on sagebrush rangelands would generally reduce annual forbs and grasses and injure perennial grasses and forbs. Their use would usually be followed by revegetation, as is the case with atrazine.

Treatment of medusahead communities with dalapon or diuron may result in dominance of cheatgrass (Evans et al. 1969b, Young and Evans 1972).

Cheatgrass is less desirable than perennial grasses but more desirable than medusahead. Herbicide treatments to control medusahead are most often followed by revegetation with perennial wheatgrasses (Young et al. 1969).

Desert Shrub

Although many desert shrublands may be dominated by undesirable species, vegetation manipulation by plant control and revegetation is difficult (Jordan 1981, Blaisdell and Holmgren 1984) (see discussion on effects of mechanical treatments). Control of dominant woody species must be followed by revegetation with desirable plants. Revegetation is usually unsuccessful on these shrublands because of the low and erratic precipitation. Treatment with herbicides would generally be expected to reduce plant cover and increase wind erosion. Soil-applied herbicides may persist many years in the Mohave Desert and retard plant reestablishment (Hunter et al. 1978).

Southwestern Shrubsteppe

Herbicides are mainly used to control woody species, such as mesquite, creosotebush, and snakeweed, in the southwest grassland (Martin 1975, McDaniel 1984). When these plants are successfully controlled, production of herbaceous vegetation may greatly increase (Cable 1976, McDaniel et al. 1982, Gibbens et al. 1987). Application of phenoxy herbicides, such as 2,4-D, to mesquite causes minimal damage to associated plants, which are generally not actively growing in late spring when these foliar-applied herbicides are most damaging to mesquite (Martin 1975). However, more recently developed herbicides, such as picloram, tebuthiuron, and dicamba, are more effective than 2,4-D in controlling many southwestern woody plants.

Picloram is recommended for controlling snakeweed (0.5 to 1 lb a.e./acre) (McDaniel 1984), and it moderately controls creosotebush and whitethorn acacia (up to 1 lb a.e./acre) (Schmutz 1967) and is more damaging to prickly pear (2 to 4 lb a.e./acre) than dicamba (2 to 4 lb a.e./acre) (Wicks et al. 1969). Picloram (0.5 to 1 lb a.e./acre) may damage desirable shrubs, such as seedlings of fourwing saltbush (Martin et al. 1970) and mature false mesquite, as well as perennial forbs (Martin and Morton 1980). Treatment of southwestern grasslands with picloram may reduce shrubs and sensitive forbs and grasses but over all should increase grass production.

Tebuthiuron is more effective than other herbicides in controlling creosotebush, and tarbush (Jacoby et al. 1982, Cox et al. 1986, Gibbens et al. 1987). However, tebuthiuron is injurious to many grasses and forbs, especially if applied during active growth (Baur 1976). Tebuthiuron treatments (0.4 lb a.e./acre) in New Mexico reduced woody vegetation and greatly increased perennial grass and annual forb production (Gibbens et al. 1987). Tebuthiuron significantly reduced brush species, including creosotebush, tarbush, wolfberry, fourwing saltbush, snakeweed, and mariola. Perennial grass basal areas were initially reduced by treatment, but total grass production of bush muhly, threeawn, bristlegrass, alkali sacaton, spike dropseed, and fluffgrass combined was 11 times greater on the treated than untreated area after 4 years. Perennial forbs, such as desert holly and hairyseed bahia, were decreased slightly by tebuthiuron treatment. Production of annual forbs, mainly desert Baileya, round leaf wildbuckwheat, and Russian thistle, was seven times higher on the treated than untreated area. Tebuthiuron applied at rates from 0.35 to 0.9 lb./acre effectively controlled sand shinnery oak and increased grass production several times (Jones and Petit 1984). Studies in New Mexico show tebuthiuron treatments of shinnery oak at 0.5 lb./acre application rate reduced shinnery oak, increased productivity of grasses, and resulted in a mixed community of grasses, forbs, and oak (Gebel 1987).

Control of creosotebush by tebuthiuron (0.4 to 1.3 lb a.e./acre) allowed seeded grasses to persist and native grasses to increase on sites in Arizona and Mexico (Cox et al. 1986). Southwestern grasslands treated with moderate rates of tebuthiuron (less than 1 lb a.e./acre) should generally have decreased woody plant production and increased herbaceous production. Certain sensitive grass, forb, and shrub species would be replaced by more tolerant species. Moderate application rates and strip treatments are recommended to minimize damage to desirable sensitive species. High rates of tebuthiuron (2 to 4 lb a.e./acre) necessary to maximize control of some species, such as mesquite (Meyer and Bovey 1979), could greatly damage understory species. Moderate application rates and strip treatments are recommended to minimize damage to desirable sensitive species.

Dicamba has been used to control undesirable herbaceous and woody species in the Southwest (Halifax and Scifres 1972). Although dicamba (2 and 4 lb a.e./acre) has been reported to injure grasses, such as blue grama and western wheatgrass (Wicks et al. 1969), established grasses usually tolerate it at application rates (0.5 to 1 lb a.e./acre) used to control rangeland brush and weeds (Halifax and Scifres 1972).

In summary, many species are sensitive to the rates and types of herbicides that are effective in controlling woody plants in the southwestern shrubsteppe. However, herbicidal treatment usually decreases woody plant growth and increases

growth of grasses. Herbaceous production usually initially decreases then increases after a few years as woody species die and herbaceous species recover and respond to reduced competition.

Chaparral-Mountain Shrub

Herbicides are used alone or in conjunction with burning, mechanical treatments, and revegetation to decrease the numbers of woody plants and increase herbaceous production in chaparral ranges. Response of shrub live oak and Gambel oak to herbicides has been studied most because these oaks are difficult to kill and dominate many areas (Van Epps 1974, Cable 1975). Most herbicides used to control chaparral shrubs are more damaging to shrubs and forbs than to grasses. These include phenoxy herbicides, such as 2,4-D, and soil- and foliar-applied herbicides, such as bromacil, dicamba, picloram, and triclopyr. When these herbicides effectively defoliate or kill overstory shrubs, grass production may double (Marquiss 1972, 1973). Burning and reseeding followed by phenoxy herbicide treatments greatly reduced oak, manzanita, ceanothus, and other shrubs and increased grass production by 770 lb/acre in Arizona (Tiedemann and Schmutz 1966). Cable (1975) indicates that chaparral areas can produce about 900 lb/acre of native or seeded perennial grasses if crown cover of sprouting shrubs is held to less than 5 to 10 percent by burning and herbicide applications.

Phenoxy herbicides, such as 2,4-D, have generally been less effective than more recently developed herbicides in controlling shrubs. For example, picloram is very effective in killing birch leaf mountain mahogany, sugar sumac, and yellowleaf silktassel (Davis and Pase 1969). Dicamba and picloram used with 2,4-D are highly injurious to menziesia, nine-bark, redstem ceanothus, and willow (Ryber 1970). Some herbicides are more effective in killing the target species and less injurious to the understory species than others. For example, triclopyr (up to 3 lb a.e./acre) controlled Gambel oak better than picloram (up to 1.2 lb a.e./acre) and was much less injurious to understory forbs, such as aster, yarrow, and lupine, in southwestern Colorado (Bartel and Rittenhouse 1979). Picloram and phenoxy herbicide treatments of chaparral should generally be expected to decrease shrub and forb cover and increase grass cover (Van Epps 1974, Kufeld 1977). Picloram treatment of chaparral sites that shed water to valley croplands could injure sensitive crops, such as cotton (Davis and Ingebo 1973). Burning Arizona chaparral 5 weeks after picloram treatment greatly reduced picloram residue but also decreased brush control (Johnsen and Warskow 1980).

Broadcasting bromacil pellets controls chaparral shrubs and causes little damage to understory grasses (Hibbert et al. 1974). Tebuthiuron is more effective than picloram in controlling some species of oak, but it also may be more damaging to understory grasses (Pettit 1974).

In general, herbicide treatments of chaparral will decrease shrub and forb cover and increase grass cover and production. Partial shrub control will result in a return to shrub dominance. High application rates necessary to control some resistant species, such as shrub live oak and Gambel oak, may drastically reduce understory perennials and allow invasion and dominance by annuals. Integrated brush management using fire, herbicides, and revegetation where necessary can convert many chaparral sites to highly productive grasslands.

Pinyon-Juniper

Picloram and tebuthiuron are soil active and are the main herbicides used to treat pinyon and juniper (Johnsen 1987). Different species of juniper vary in their sensitivity to these herbicides, but more species are sensitive to picloram than tebuthiuron. Tree mortality varies with species, site, rate, and type of application (Johnsen 1987). Response of understory species to treatment is dependent on the tree mortality and on the sensitivity of the understory species to the herbicides. Both picloram and tebuthiuron persist in the soil for some years and may injure understory grasses, shrubs, and forbs. Individual tree treatments with these herbicides may be more effective in controlling the trees and less injurious to understory species than broadcast applications (Evans et al. 1975, Johnsen 1987). Evans et al. (1975) discouraged broadcast treatments of picloram because many stands lack sufficient understory species to respond to tree control, and species that are there may be injured by picloram. They recommended spot treating of pinyon-juniper stands with picloram or using picloram as a followup treatment after chaining. They also cautioned that using picloram on some sites could result in dominance by annual grasses, such as cheatgrass or medusahead, because they are resistant to picloram (Evans and Young 1985).

However, Johnsen (1987) notes that picloram applied to individual trees caused little damage to associated understory species and that aerially applied picloram (4 lb a.e./acre) did not damage blue grama or side-oats grama grasses in Arizona. In contrast, tebuthiuron may kill understory grasses and forbs several feet away from individually treated trees. High rates of aerial-applied tebuthiuron (4 lb a.e./acre) killed cool-season grasses in Arizona. However, the lower recommended aerial application rates of both picloram and tebuthiuron (2 lb a.e./acre) resulted in good stands of perennial grass within 5 years on sites that had residual grass stands at treatment.

Plains Grassland

Herbicides are used on plains grasslands to control some woody plants, such as sand sagebrush (Bovey 1964) and fringed sagebrush (Smika et al. 1963), but are mainly used to control noxious herbaceous weeds, which include musk thistle (Roeth 1979), Canadian thistle (Gallagher and Vanden Born 1976), knapweed (Hubbard 1975), ragweed (McCarty and Scifres 1972), and leafy spurge (Bowes and Molberg 1975). Herbicides also are used to help establish forage grasses (Morrow and McCarty 1976). Herbicides most commonly used include 2,4-D, picloram, and dicamba. Bromacil and atrazine may also be used for weed control before seeding perennial grasses. Atrazine may be used to increase protein content and drought tolerance of grasses, such as blue grama (Houston 1977).

Control of broadleaf plants by selective herbicides, such as 2,4-D, usually increases grass production. Application of 2,4-D (2 lb a.e./acre) to mixed prairie decreased broadleaf shrubs and forbs, such as fringed sagebrush, curly cup gumweed, star lily, milkvetch, hairy aster, blue-bells, and evening primrose, and increased some grasses and forbs, such as thickspike wheatgrass, western wheatgrass, and globe mallow (Hyder 1971). Control by 2,4-D (2 lb a.e./acre) of weedy forbs, such as annual saltbush, kochia, and Russian thistle, increased production of needlegrass and wheatgrass (Nichols and McMurphy 1969).

Picloram may damage sensitive grasses as well as broadleaf plants. Picloram (1 lb a.e./acre) applied with or without 2,4-D controlled snakeweed and prickly pear and initially damaged blue grama and needle-and-thread grass (Gesink et al. 1973). The grasses recovered and had increased production 5 years after treatment. Needle-and-thread grass was more tolerant to picloram than blue grama, and production increased on needle-and-thread grass plots treated at low rates. Picloram may selectively reduce forbs and some grasses. Picloram (0.75 to 4 lb a.e./acre) decreased yarrow, aster, and ironweed, and some grasses, such as blue and hairy grama, but picloram did not decrease little and big bluestem, indiangrass, or switchgrass (Arnold and Santelmann 1966). These studies illustrate how picloram may affect plant community composition when species of different sensitivity are present.

Herbicides commonly used on plains grasslands for weed control before revegetation may initially damage grass seedlings. Picloram (0.75 to 3 lb a.e./acre) reduced seedling emergence of side-oats grama, big bluestem, switchgrass, and blue grama, but big bluestem was more tolerant than the other species (Arnold and Santelmann 1966). Picloram (0.5 lb a.e./acre) controlled knapweed and allowed establishment of wheatgrasses (Hubbard 1975). Creeping red fescue and timothy were tolerant of picloram (0.25 lb a.e./acre) and dicamba (0.5 lb a.e./acre) used to control Canada thistle if they were seeded one growing season after herbicide application (Gallagher and Vanden Born 1976).

Atrazine may be used to control annual weeds in warm-season grasses that are normally tolerant, except at the seedling stage (Bahler et al. 1984). Seedlings of Caucasian bluestem and switchgrass were more tolerant to atrazine (3 ppm in greenhouse soil) than indiangrass, sideoats grama, and blue grama (Bahler et al. 1984). Atrazine (1.8 lb a.e./acre) applied to a shortgrass prairie in Colorado controlled annual forbs and grasses and reduced the frequency of cool-season grasses, such as squirreltail, western wheatgrass, and needle-and-thread grass (Houston 1977). Frequency of warm-season grasses, such as blue grama, threeawn, and sand dropseed increased, as did that of some perennial forbs, hairy gold aster, and rush skeleton plant.

Applications of selective herbicides, such as 2,4-D, on plains grasslands may be expected to increase grasses and decrease broadleaf species. Applications of picloram and atrazine to control noxious herbaceous and woody weeds or to control annuals before revegetation may favor or disfavor certain broadleaf and grass species, depending on relative herbicide sensitivity. These herbicides can greatly change the composition of mixed prairie communities.

Mountain/Plateau Grasslands

Mountain and plateau grasslands have generally been treated with herbicides when they are dominated by weedy shrubs and forbs. Application of 2,4-D (3 lb a.e./acre) to degraded meadows in Colorado controlled silver sagebrush and decreased forbs such as agoseris, eriogonium, sneezeweed, lupine, and vetch, as well as dandelion and cinquefoil (Turner 1969). In that study, grasses and sedges increased greatly in cover and production after shrub and forb control. Species composition of grasses did not change greatly after herbicide treatments, and some forbs, such as cinquefoil, though initially set back, had high frequency 9 years after treatment. In Wyoming, application of 2,4-D (1,2 and 4 lb a.e./acre) decreased the cover and production of forbs such as lupine, avens, agoseris, pussytoes, arnica, and cinquefoil (Hurd 1955). Some forbs, such as yarrow, sandwort, cerasticean, and bedstraw, were tolerant of 2,4-D, while others, such as aster, eriogonium, and phlox, were moderately sensitive to the herbicide. Cover and production of grasses and sedges increased relative to untreated plots. Application of 2,4-D (1, 2, 3 and 4 lb a.e./acre) to mountain grasslands in Nevada to control iris also greatly reduced dandelion and yarrow the first year

after treatment (Eckert et al. 1973b). Production of slender wheatgrass, Nevada bluegrass, and meadow barley greatly increased after iris control. Treatment of mountain grasslands with selective herbicides, such as 2,4-D, can be expected to increase production of grass and grasslike plants and decrease production of shrubs and forbs. Forbs that are tolerant of 2,4-D or can readily reestablish from seed will persist in the meadow communities.

Coniferous/Deciduous Forests

Chemical treatments would affect the species composition, size, density, and vigor of the vegetation in coniferous/deciduous forests. These impacts may range from complete control of target vegetation to negligible damage, depending on species, chemicals used, dosages, and timing of applications.

Herbicides such as picloram, triclopyr, glyphosate, and atrazine may result in brush and hardwood defoliation, top kill, and minimal resprouting. These treatments would temporarily reduce competitors, increase the amount of light reaching conifers and other desirable species, and decrease bush and grass competition for soil, moisture, and nutrients. Impacts would be greater on plant sprouts and seedlings than on full-grown plants. Using herbicides can increase the growth rate of conifer seedlings stressed by competition. Herbicide injections would leave trees standing and would create additional fire hazards from the dead needles or leaves.

CLIMATE AND AIR QUALITY

Climate

Because the factors influencing climate are so large in scale compared with the size of any individual proposed vegetation treatment, none of the vegetation treatment methods would have any significant impact on the climate.

Global carbon dioxide and methane levels are increasing, and have been called "greenhouse gases," implying their increased concentrations may lead to changes in precipitation and temperature (both in timing and intensity). All vegetation is important in the processing and recycling of oxygen and carbon through photosynthesis. By converting carbon dioxide into oxygen and plant fiber, carbon is "fixed;" removed from the atmosphere until the plant material either decomposes or burns. Grasslands may fix carbon at a faster rate than woody vegetation types, but the total mass of fixed carbon is much less. Of the treatment methods considered, prescribed burning has the greatest potential for adding carbon dioxide and fine particulate matter to the atmosphere.

Although the "greenhouse effect" theory is very popular, the probability of its occurrence and potential effects are unknown at this time. To validate the theory, a multi-year, multi-million dollar research program was established by President Bush, and is administered by the interagency Committee on Earth Sciences. The Bureau of Land Management is a participating agency in this research.

Air Quality

The most significant impacts on air quality would be moderate increases in noise, dust, and combustion engine exhaust generated by manual and mechanical treatment methods; smoke from prescribed burning; and moderate noise and minimal chemical drift from aerial application of herbicides. Impacts would be temporary, small in scale, and quickly dispersed throughout the EIS area. These factors, combined with standard management practices (stipulations), minimize the significance of potential impacts. Federal, State, and local air quality regulations would not be violated.

Potential air quality impacts are assessed before project implementation. Site-specific plans are reviewed for compliance with applicable laws and policies, and existing air quality is inventoried so that changes associated with BLM proposals may be determined. Additional mitigation may be incorporated into specific project proposals to further reduce potential impacts. For example, prescribed burning activities must comply with the BLM Manual, Sections 9211.31(E), Fire Planning, and 9214.33, Prescribed Fire Management, to minimize air quality impacts from resulting smoke. This procedure requires compliance with individual State and local smoke management programs that specify the conditions under which burning may be conducted. Similarly, standard management practices for aerial application of herbicides limit the amount of drift into nontarget areas.

Manual and Mechanical Methods

Fugitive (wind-blown) dust from manual or mechanical equipment would have a localized, temporary impact. Power equipment and machinery exhaust would emit carbon monoxide, sulfur dioxide, and nitrogen dioxide; however, the quantities would be so small that their isolated and temporary use would not cause significant impacts. Noise levels could approach 90 decibels (dbA) for short time periods, but no long-term impacts are anticipated. Impacts would not vary significantly by vegetation analysis region. Standard management practices would limit impacts to the immediate vicinity of the treatment area.

Biological Methods

Biological treatments, which do not use machines or chemicals, have little potential to affect air quality. Biological treatments may cause minor odors because of confined animals, but these effects would be restricted to the immediate treatment area and would dissipate rapidly. Impacts would not vary significantly by analysis region, because the area treated by biological methods remains nearly constant for all alternatives.

Prescribed Burning

Particulate matter, volatile organic compounds, and carbon monoxide are the primary pollutants emitted during prescribed burning that would affect air quality. Compliance with local smoke management programs would minimize these effects. The timing, vegetation type, size of burns, fuel arrangement and moisture, ignition techniques and patterns, and weather conditions are all specified to keep smoke amounts within acceptable limits. The actual level of impact depends on a combination of all these factors, but regardless of the burning conditions, air-quality regulations would be met. The health effects of prescribed burning are described later in this chapter and detailed in Appendix D.

Table 3-5 summarizes air pollutant emissions due to prescribed burning by program alternative. Potential cumulative impacts may occur when multiple prescribed fires occur simultaneously. In the Pacific Northwest (where cumulative impacts are most likely), smoke management committees limit burning by Federal, state and private groups to minimize cumulative impacts.

Table 3-5

Annual Prescribed Burning Pollutant Emissions by Program Alternative (tons)

	Program Alternative				
Pollutant	Proposed Action	No Aerial Herbicide	No Herbicide	No Burning	No Action
Carbon Monoxide	29,400	36,500	37,100	0	23,900
Nitrogen Oxides	1,300	1,700	1,700	0	1,100
Sulfur Dioxide[1]	—	—	—	—	—
Total Suspended Particulates	4,800	6,300	6,400	0	4,200
Inhalable Particulates	3,200	4,100	4,200	0	2,700
Volatile Organic Compounds	6,300	8,400	8,600	0	5,800
Acres Burned	97,765	132,290	136,390	0	92,680

[1] Sulfur dioxide emissions are negligible.

Fuel Loading:

Chaparral	- 3 tons/acre
Coniferous	- 6 tons/acre
Grasslands	- ½ ton/acre
Pinyon-Juniper	- 5 tons/acre
Sagebrush	- 3 tons/acre
Activity fuels	- 15 tons/acre

Fuel Consumption: 100 percent.
Emission Factors: U.S. Environmental Protection Agency (1989).

Chemical Methods

Spray drift and volatilized chemicals from aerial, ground vehicle, and hand applications of herbicides could occur, but would not significantly affect air quality. Spray droplets of 100 microns and less are most prone to drift, and may be carried long distances before reaching the ground. Standard management practices that can minimize these impacts include using spray equipment designed to produce 200- to 800-micron-diameter droplets and prohibiting spraying when the wind speed exceeds 6 miles per hour or blows in the wrong direction. Health risks associated with chemical drift are discussed later in this chapter and are detailed in Appendix E. Ester formulations of 2,4-D or triclopyr applied in diesel oil are prone to volatilization; all other herbicides are less volatile. The use of ground vehicles and aircraft to apply the herbicides could temporarily cause noise levels to reach 90 dbA; however, no long-term effects are anticipated.

GEOLOGY AND TOPOGRAPHY

Geology interacts either directly or indirectly with all other environmental factors. For example, the rock type of a specific area can exert a major influence in controlling soil development, vegetation community composition, and plant growth rates. Soil moisture retention is indirectly related to the geologic material and weathering conditions. The environmental resources that are most closely associated with the geology include soil resources and water resources. The possibility of increased soil erosion or accumulation of chemical herbicides in soils are potential impacts of the various vegetation treatments. Alternative treatment programs are specifically identified and discussed in the Soils section. Potential impacts to water resources from either increased sediment yields or increased chemical herbicides resulting from vegetation treatments are discussed in detail in the Aquatic Resources section. Although these related resources may be affected, the implementation of vegetation treatment alternatives and the application of the methods considered in this EIS are not expected to directly affect geologic resources.

Topography typically is linked to the area geology and also is a consequence of many interacting environmental factors. The topography of an area may serve to restrict the distribution of certain vegetation communities because of the climate associated with that area's elevation. Certain topographic highs (mountain ranges) influence weather patterns and cause a "rain shadow" effect on much of the interior regions of the American West, causing leeward areas to receive less moisture than the windward areas. Treatment programs that use mechanical equipment (that is, tilling, bulldozing, etc.) have the recognized capacity to produce minor changes in the topographic landscape. However, the implementation of vegetation treatment alternatives and the application of the methods considered in this EIS are not expected to substantially affect topography.

SOILS

Vegetation treatments may affect the physical characteristics of soils directly, alter the abundance and types of vegetation that may shield soils from erosion, or alter the presence and abundance of soil microorganisms or larger organisms that contribute to overall soil quality.

Manual Methods

The disturbance of soils caused by manual methods of vegetation treatment should be negligible. Because manual vegetation methods generally are reserved for small isolated areas (because of labor expenses) and because they do not directly affect the surficial organic layer of the soil, this treatment method will not be evaluated on an analysis region basis. Overall, manual treatment effects on soils should be minimal compared with those that may occur with the mechanical treatments described in the following sections.

Mechanical Methods

The effects of mechanical treatments on soils and their hydrologic characteristics depend on the following: (1) soil exposure following treatment; (2) the direct effect of soil disturbance on soil properties; and (3) the site conditions, especially precipitation pattern and slope. Mechanical methods include two general types: (1) methods such as mowing and roller chopping, which remove top growth but do not directly disturb the soil, and (2) methods such as plowing and chaining, which can remove the entire plant, including roots, and directly disturb the soil (Blackburn 1983).

Plant and litter cover protect the soil, and roots hold the soil in place, so lack of plant cover is highly correlated with runoff and erosion on rangelands (Rauzi 1960, Rauzi and Fly 1968, Branson et al. 1981). Any reduction in cover by vegetation manipulations would tend to increase runoff and erosion on rangeland watersheds. Mechanical treatments

are designed to increase plant cover by encouraging the growth of nontarget species already present or by facilitating artificial revegetation. Vegetation treatment aimed at reducing woody species and increasing herbaceous species greatly reduces water runoff and erosion while improving soil stability. Where revegetation is necessary to produce desired cover after plant control, the hydrologic response to control may be greatly dependent on the success of revegetation. For example, disk plowing sagebrush and drilling beardless bluebunch wheatgrass reduced bareground by 30 percent and decreased runoff and erosion at sites in Colorado (Lusby 1979). However, plowing and unsuccessful revegetation of sagebrush in Nevada decreased infiltration rates (Gifford 1968, Jager 1972). Effects of mechanical vegetation manipulation on soils must be evaluated with respect to the effects of the treatment on total vegetation cover compared to nontreated rangeland.

The direct effects of mechanical disturbance on soils depend on the type and extent of disturbance, the soil texture and structure, and the soil water content when disturbed. Although little data are available on the direct effects of mechanical disturbance on rangeland soils, literature from tillage of agricultural soils suggests some principles. Soil aggregate stability is necessary for high infiltration rates and soil stability. Aggregate stability is maintained by vegetation cover, which protects the aggregates from raindrop impact, and by soil organic matter, which holds aggregates together (Tate 1987). Lack of soil aggregation results in formation of a surface crust, especially on fine-textured soils, which reduces infiltration, soil aeration, and associated plant growth (Cary and Evans 1974). Some rangeland soils have pronounced vesicular crusts in the interspaces between tree, shrub, and grass plants. These crusts have poor structure and much lower infiltration rates than the well-aggregated soils under the shrubs or trees (Blackburn and Skau 1974). Mechanical treatment disturbance of these and other crusted soils could be expected to increase infiltration for a while, but unless soil vegetation cover, organic matter, soil aggregation, and porosity are increased in association with vegetation response to the treatment, the crusts will reform and infiltration will continue to be low. Thus, the effects of mechanical treatments on crusted soils are highly dependent on vegetation response after treatment. A high cover of vegetation protects and maintains soil aggregation by reducing raindrop impact and by adding organic matter (Cary and Evans 1974).

Mechanical treatments such as disking or tilling are designed to aerate, lift, twist, shear, and incorporate the surficial vegetative cover and organic matter into the soil. This mixing adds important organic nutrients to the root zone and facilitates the establishment of newly planted vegetation. However, mechanical treatments may possibly increase runoff and erosion on some highly sloping sites, especially the fine-textured, unstable, crusted soils that are present on some sagebrush and desert shrub rangelands. In addition, the mechanical treatment and suppression of nitrogen-fixing vegetation (that is, Ceanothus spp.) may result in a dramatic reduction in the abundance of nitrogen-fixing bacteria. Recovery of infiltration rates and sediment control on some sites generally occurs with time, depending on the speed of natural or artificial revegetation and replacement of vegetation cover.

Soil texture and morphology also affect soil response to mechanical treatments. Coarse-textured soils with initially high infiltration rates and clayey soils with low infiltration rates generally would be expected to change little after direct mechanical disturbance. However, if the mechanical treatment creates furrows or pits to hold water or breaks up a shallow soil layer of limited permeability, infiltration may be increased (Brown et al. 1985). Herbel (1984a) recommended no mechanical treatment of sandy soils in windy areas because of the resulting increase in wind erosion when vegetation cover is lost.

Effects of mechanical treatments also are highly dependent on precipitation pattern and ground slope. Temporary loss of vegetation cover from mechanical treatments may result in increased erosion from high-intensity summer thunderstorms; however, erosion from gentle winter snow and rainfall probably would be limited. For example, converting sagebrush to grass by plowing and seeding reduced summer rainfall runoff but increased snowmelt runoff (Lusby 1979). Because most of the sediment production and runoff was associated with summer runoff, the conversion decreased erosion and runoff overall.

Many mechanical methods are limited to ground slopes of less than 30 percent; however, erosion hazards are greatest on slopes greater than 20 percent (Jordan 1981). Thus, mechanical methods have the potential to greatly increase erosion on steep slopes but in practice are most frequently used on gentle slopes where the erosion hazard is limited.

A recognition of the negative impacts of recurrent disturbance has resulted in an emphasis on minimum tillage of agricultural soils (Donahue et al. 1977). Hutten and Gifford (1988) found that frequently plowed agricultural soils had overall lower infiltration rates and higher sediment production than adjacent rangeland soils. Although the frequency of rangeland soil disturbance with mechanical plant control is much less than that of tilled agricultural soils, mechanical compaction of rangeland soils has long been identified as a potential problem (Lull 1959). Direct impacts associated with mechanical disturbance will be highly site- and treatment-

specific, but negative impacts would be most expected on fine-textured soils lacking organic matter and soil structure with low aggregate stability and a tendency to form a crust. Soil compaction symptoms and causes have been discussed by Robertson and Erickson (1978). Compaction from mechanical treatments of rangeland soils should be much less than agricultural soils. Heavy machinery driven over rangeland soils to control vegetation may compact surface and subsurface soils and reduce aggregation. Range management equipment that disturbs the soil may break down large aggregates to smaller, less stable aggregates. Compaction is especially pronounced on wet and poorly drained soils.

The general impacts of mechanical treatments on rangeland vegetation and soils have been summarized by Blackburn (1983). Cutting and mowing methods, such as roller chopping, result in minimal physical soil disturbance and may produce soil-protecting mulch. The soil disturbance produced by grubbing, bulldozing, and chaining/cabling increases with increased density of the woody target species. Soil disturbance by these methods may be extensive, but pits created by plant extraction and debris left in place may trap water and limit runoff and erosion. Rootplowing and disk plowing completely disturb the surface and sometimes the subsurface soil.

Conversion from woody to herbaceous vegetation would not necessarily increase water yields from rangeland watersheds, but if vegetation cover is maintained by existent and seeded herbaceous plants after mechanical disturbance, runoff and erosion should decrease. Revegetation to replace lost cover would be recommended to reduce potential erosion on windrowed sites. Increased surface roughness after mechanical disturbance may decrease runoff and erosion of some noncrusting soils as long as vegetation cover is not greatly reduced. Coarse-textured soils of many rangelands would continue to maintain similar infiltration and sediment production rates after mechanical treatment.

Although various literature sources discuss the efficacy of mechanical control treatments, data that detail the impacts of these treatments are sparse (Blackburn 1983). Sagebrush and pinyon-juniper sites have been most studied to determine effects of mechanical treatments on soils and hydrology. Impacts of plant control on soils and hydrology are extremely variable because of interactions of weather, control method, vegetation response, soil properties, and post-treatment management (Blackburn 1983). Because these interactions are not understood in detail, predictions of treatment responses are difficult to make on specific sites that have not been researched.

Sagebrush

Since 1940, millions of hectares of sagebrush have been cleared in the Western United States. The limited information on impacts from mechanical disturbance varies with the site and treatment (Blackburn 1983). Parker (1979) has reviewed the various mechanical methods for controlling sagebrush, and Blaisdell et al. (1982) discuss their application to specific sites.

Disk plowing of sagebrush and drill seeding of beardless bluebunch wheatgrass in Colorado quadrupled herbaceous forage production and decreased summer runoff and annual sediment yield by 75 and 80 percent, respectively, on a watershed scale (Lusby 1979). Infiltration decreased and sediment production increased after plowing sagebrush and unsuccessfully seeding perennial grass in Nevada on silt-loam soils (Gifford 1972). The failure to replace vegetation cover and the crusted nature of these fine-textured soils may account for the negative response to plowing in this study. Similar crusted soils in Nevada had increased sediment production after disturbance by off-road vehicles (Eckert et al. 1979).

On a sagebrush site in Idaho, infiltration rates decreased after plowing and seeding grass but recovered after 6 years (Gifford 1982). Hydrologic characteristics of some sagebrush sites in Nevada were similar or improved 6 to 17 years after plowing and seeding the grass (Blackburn and Skau 1974). In these studies, the presence of a vesicular crust most negatively affected infiltration. Soils with a vesicular crust that are disturbed are highly unstable and may produce suspended sediment with intense rainshowers. Blackburn and Skau concluded that mechanically converting sagebrush to grass may not affect infiltration rates of soils without a vesicular crust and may, only after some time, improve infiltration rates on soils with a vesicular crust, possibly as vegetation cover, soil organic matter, and aggregate stability increase. In another study in Nevada, plowing and seeding grasses reduced infiltration rates and increased sediment production immediately after treatment, but after 2 years infiltration rates were recovering and sediment production was similar to that of control plots (Brown et al. 1985). In this study, furrows created by plowing and seeding retarded runoff, indicating a possible lower erosion hazard from mechanical disturbance than would be inferred from infiltration-rate data alone.

In summary, mechanical disturbance to control sagebrush may or may not initially adversely affect soil hydrologic properties, and adverse effects tend to decrease with time after disturbance. There is a lack of watershed-scale data and data on specific soil structural characteristics as affected by mechanical disturbance in the sagebrush ecosystem. The

movement of suspended sediment from the usual gentle slopes of the sagebrush rangelands is not known (Eckert et al. 1979). Most of the precipitation on sagebrush rangelands falls in the winter as snow or gentle rains and would not be expected to greatly erode disturbed soils. However, infrequent, highly localized, intensive summer thundershowers could erode recently disturbed soils. Effects of mechanical control on sagebrush soils probably are most dependent on the replacement of lost vegetation cover by desired species.

Desert Shrub

Mechanical or other methods of plant control generally are not recommended for desert shrubland (see section on Vegetation). Replacing perennial plant cover by revegetation is usually necessary after plant control. Revegetation is rarely successful, so disturbance of existing plant cover tends to increase annual weed cover and bare ground.

Mounds associated with shrubs on some soils of the desert shrubland have well-aggregated soils with much higher infiltration rates (Blackburn 1975) and a higher concentration of nutrients than soils between the mounds (Charley and West 1975). Mechanical disturbance of these soils could reduce infiltration rates and nutrient cycling, resulting in less vegetation cover and increased bare ground and erosion hazard. Although slopes of these rangelands usually are gentle, runoff and water erosion can be high due to high-intensity rainstorms resulting from the inherently low vegetation cover. Disturbance of shrub mounds, and especially shrub interspaces with unstable, fine-textured, vesicular-crusted soils, can greatly increase sediment production (Eckert et al. 1979). Loss of vegetation cover would be expected to greatly increase wind erosion on these lands (Herbel 1984a).

Southwestern Shrubsteppe

Mechanical methods, such as chaining and rootplowing, have been used to control woody plants, especially mesquite, throughout the Southwest (Jordan 1981). Most of the literature on hydrologic and soil impacts associated with mechanical mesquite control is from Texas (Blackburn 1983). Soils in the Southwest are vulnerable to erosion by high-intensity summer rain showers. Although Martin (1975) observed that increases in mesquite may accelerate sheet and gully erosion in semidesert grassland, there is a lack of research evaluating hydrologic responses to mesquite control. Rootplowing of honey mesquite increased infiltration and reduced sediment production of shrub interspaces on the Texas Rolling Plains (Brock et al. 1982).

Plant cover is most important in maintaining high infiltration rates after mechanical disturbance on the clay-loam soils of this region. Complete denudation of a mesquite-buffalograss community in Texas, using herbicides and shredding, decreased infiltration and increased runoff and sediment production (Bedunah and Sosebee 1985). Shredding and power grubbing of mesquite resulted in runoff and sediment production similar to untreated plots. Rootplowing of creosotebush sites on coarse-textured soils in Arizona reduced runoff by increasing surface roughness and detention storage and by increasing plant cover (Tromble 1976). In a subsequent study in New Mexico (Tromble 1980), rootplowing creosotebush and seeding grasses resulted in less vegetation cover and lower infiltration rates than untreated areas. Infiltration rates increased on rootplowed areas after 4 years, when seeded grass cover had increased.

Mechanical treatments may increase infiltration of some soils in the Southwest by increasing surface roughness. Because vegetation cover is extremely important in protecting the soil from high-intensity thundershowers, the change in cover after treatment generally determines any change in runoff or erosion. Mechanical control should be used only on sites with a high potential for natural or artificial replacement of vegetation cover after removal of undesirable species.

Chaparral-Mountain Shrub

Since chaparral vegetation occurs on steep and rocky terrain, mechanical control methods have had limited application (Ffolliott and Thorud 1975). Rootplowing, which is possible on only about 2 to 8 percent of chaparral (Pond 1961), is considered to be the most effective mechanical method for chaparral control (Cable 1975). Rootplowing of live oak on the Edwards Plateau created large storage depressions and reduced runoff by 20 percent (Richardson et al. 1979). Grubbing shrubs and seeding perennial grasses reduced erosion by 99 percent over a 7-year period in Arizona, probably by greatly increasing grass basal area and ground cover (Rich 1961).

Roby and Green (1976) have reviewed other methods of mechanical treatment of chaparral. They observed that chaining and disking may disturb the soil and increase erosion hazards, while chopping methods that leave roots intact and produce a mulch have less potential for causing erosion. Because successful mechanical control by rootplowing is only possible on the more gentle slopes and is always accompanied by restoration of groundcover by revegetation, it is not expected to adversely affect soils and hydrology in the chaparral type. Control by topkill methods, such as chaining and shredding, reduces live plant cover and briefly increases ero-

sion hazard, but most plants quickly resprout from basal buds and cover is rapidly restored. Although severe erosion could occur on steep slopes if high-intensity rainfall occurs before plant cover reestablishment, some treatment practices can be done on contour to help mitigate the problem.

Pinyon-Juniper

The low precipitation and resulting small surface-water budget of pinyon-juniper watersheds results in low ground-water recharge, runoff, and erosion compared to many watersheds (Hawkins 1987). Because much of the hydrologic activity is soil-water recharge rather than runoff, hydrologic prediction techniques are not easily applied and are limited by lack of site-specific calibration data (Hawkins 1987). Thus, information on the response of pinyon-juniper soils to mechanical treatments is mainly from empirical studies on specific sites, and reasons for varying responses are not easily determined.

Mechanical methods used to control pinyon-juniper include chaining or cabling, bulldozing, and handslashing (Blackburn 1983). These trees are controlled not only to increase forage production, but also to increase water yield from selected watersheds. Cabling Utah juniper on the Beaver Creek watershed in Arizona created pits that trapped overland flow and resulted in water yields and sediment production similar to those in untreated areas (Skau 1961, 1964). Chaining, grubbing, girdling, and handslashing 25 percent of the pinyon-juniper did not change water yield of the Corduroy Creek watershed in Arizona (Collings and Myrick 1966). In southern Utah, chaining and windrowing pinyon-juniper debris slightly reduced infiltration and increased streamflow, while double-chaining and leaving debris in place resulted in infiltration and water yield similar to that of untreated sites (Gifford 1975, Williams et al. 1972). Sediment production from chained pinyon-juniper sites in Utah generally was no greater than that from untreated woodland except when the debris was windrowed (Williams et al. 1969, Gifford et al. 1970, Gifford 1975).

These studies emphasize again that treatments that reduce cover, such as windrowing, have the greatest potential for increasing erosion. In Nevada, Blackburn and Skau (1974) found no statistical difference in infiltration or sediment production between chained and untreated pinyon and juniper communities measured 3 and 11 years post-treatment. The chained areas had a grass cover from revegetation and showed a trend toward less sediment production than untreated areas. In general, mechanical treatments of pinyon-juniper on coarse-textured soils do not appear to significantly affect runoff and erosion. Although leaving debris in place to cover the soil instead of windrowing reduces erosion potential, using chaining treatment operations combined with prescribed burning operations of the debris and planting of desired vegetation species has been particularly successful. Site-specific conditions and treatment program objectives determine the variety of treatment methods and their general application.

Plains Grasslands

Mechanical treatments of plains grasslands (generally tilling or ripping to break up compacted soils and sod-bound vegetation) are conducted to reduce less desirable warm-season species and to increase production of cool-season species (Griffith et al. 1985). Because the treated slopes are gentle and plant cover recovers rapidly after disturbance, water erosion potential generally is low. Tilling and ripping are done in strips to prevent large ground cover loss and to avoid the type of wind erosion that occurred on tilled lands in the 1930s (Lorenz 1986). Tillage associated with interseeding increased soil water content and evidently released nutrients by increasing soil weathering and organic matter decomposition (Wright and White 1974). Strip mechanical treatments on plains grasslands generally result in positive rather than negative soil water relations for plant growth and have positive hydrologic responses.

Mechanical treatments generally increase soil water storage by trapping snow and increasing infiltration (Wright and Siddoway 1972, Neff and Wight 1977). For example, contour tilling in Montana decreased runoff in late fall and early spring and increased snow accumulation (Neff and Wight 1977). This increased over-winter soil water recharge .44 and 1.56 inches on saline upland and on pan-spot range sites, respectively. Tilling increased soil water content and decreased salinity of the surface soil in Montana (Branson et al. 1966). The leaching of salts associated with furrowing was seen as beneficial in that study because pretreatment salinity was high enough to reduce the osmotic potential of the soil solution and reduce plant growth.

In summary, mechanical treatments of plains grasslands generally would result in increased aeration and mixing of organic material. Recovery of infiltration rates and sediment control on some sites generally occurs with time and probably is dependent on natural or artificial revegetation and replacement of vegetation cover. Increased surface roughness after mechanical disturbance may decrease runoff and erosion of some noncrusting soils as long as vegetation cover is not greatly reduced.

Coarse-textured soils of many rangelands continue to maintain similar infiltration and sediment production rates after mechanical treatment. Con-

version from woody to herbaceous vegetation does not necessarily increase water yields from rangeland watersheds (Blackburn 1983), but if vegetation cover is maintained by existent or seeded plants after mechanical disturbance, runoff and erosion should not increase. Revegetation to replace lost cover is recommended to reduce potential erosion on windrowed sites. Plains grassland slopes are gentle, and plant cover would recover rapidly after disturbance, so water erosion potential generally would be low.

Mountain/Plateau Grasslands

Mountain/plateau grasslands are similar to plains grasslands, except that they are not as laterally extensive, are often surrounded by higher elevation areas, and may be immediately adjacent to forest communities. Mechanical treatments of these grasslands, conducted by furrowing or ripping to break up compacted soils and sod-forming vegetation, generally would result in increased aeration and mixing of organic material.

Tillage associated with interseeding increased soil water content and evidently released nutrients by increasing soil weathering and organic matter decomposition (Wright and White 1974). Strip mechanical treatments on mountain/plateau grasslands generally result in positive rather than negative soil water relations for plant growth and have positive hydrologic responses. Mechanical methods of vegetation treatment may increase runoff and erosion on some sites, especially those with fine-textured, unstable, and crusted soils. Recovery of infiltration rates and sediment control on some sites generally occurs with time and probably is dependent on natural or artificial revegetation and replacement of vegetation cover. Increased surface roughness after mechanical disturbance may decrease runoff and erosion of some noncrusting soils as long as vegetation cover is not greatly reduced.

Coniferous/Deciduous Forest

Mechanical treatments in forests consist primarily of slash piling of cut vegetation and scarification (soil preparation) using crawler tractors to facilitate the establishment of newly planted seedlings. The mechanical methods typically used in the forest ecosystem have a higher potential than any other vegetation management method for direct impacts to soils (Newton and Norgren 1977). Soil disturbances from scarification and construction of tractor trails may cause soil compaction (Froehlich 1973). Reductions in rooting depth (USDA 1988), soil productivity (Froehlich, 1973), and mycorrhizal fungal mycelia (Perry and Rose 1980) may be associated with this compaction. Mycorrhizal fungal mycelia are particularly important for water and nutrient uptake in most plant species and are closely linked to soil productivity. Because soil compaction problems resulting from vegetation treatment operations are intensified when soils are saturated, limiting these types of operations to drier periods can minimize detrimental soil compaction and subsequent reductions in soil productivity. The construction of slash piles also may remove some of the protective duff layer from forest soils. This duff disturbance may increase the potential for accelerated surface erosion and removal of productive topsoil, especially on steeply sloped areas. Mechanical treatment programs that use wheeled or crawler tractors in timber harvesting and planting are designed to limit mechanical methods to those stable, low-sloped areas that are not highly susceptible to erosion and soil removal.

Biological Methods

Biological methods of vegetation treatment that BLM may consider using include grazing animals, insects, and pathogens. The size of areas used for biological treatment would depend on the target plant species and the method of treatment. The areas treated using these methods would vary in size from one-quarter acre to 1,500 acres for insects or pathogens, and 5 to 500 acres for grazing animals. The impacts of these treatment methods will vary depending on the size of the treatment area and the method used. Insects and pathogens generally should have a lesser impact because of the slower, more "natural" action of this method, while the use of grazing animals for biological treatment has greater potential for impacts because of the animals' greater size and more immediate disturbance of the sites. Most studies of the effects of grazing on soils deal with general grazing practices. The main effects on soils caused by grazing include compaction of wet soils from trampling and surface erosion on hillsides due to loss of plant cover from overgrazing. However, these effects usually would not occur when grazing practices follow a specifically planned vegetation management program.

Livestock would be closely controlled to prevent damage to desired vegetation. This supervision of the livestock, in addition to fencing and upslope water developments, also would be used to keep livestock from concentrating in wet areas and overgrazing to the point that desired vegetation is damaged. Livestock could potentially create a disturbance of lichen and moss cover in certain areas and increase soil surface exposure, although proper grazing management practices should minimize any adverse impacts. Possible impacts would vary according to site, depending on size and the grazing management techniques used. In general, impacts will be negligible on smaller biological treatment sites and slight on larger sites.

There is little potential for direct soil impacts from insect and pathogen biological vegetation treatments because these programs are longer in duration and slower in action than many other treatment methods and usually leave the target plants standing, thereby reducing the effects to the soil. The organisms used in biological treatment methods are directed at modifying the frequency and occurrence of certain targeted plant species and have little interaction with soil.

Prescribed Burning

Fire plays both an evolutionary and ecological role in shaping most ecosystems in the West; however, prescribed burning has gained widespread acceptance as a land management tool only in the past two decades (Wright and Bailey 1982). Prescribed burning techniques allow managers to perform burns under previously set conditions. Prescribed fires usually are staged under burning conditions that may not only mitigate or limit adverse impacts to soils, but also actually improve soil conditions. This discussion will concentrate on fire effects from prescribed burns rather than wildfires. Results from studies of wildfires are difficult to interpret because of the widely varying environmental conditions under which they occur and the fact that these conditions are rarely documented. Nor are these fires carefully monitored in most instances (Wright 1974b, Buckhouse 1985).

The following discussion of prescribed fire impacts will describe general effects of fire on soils/watersheds, followed by specific effects on the various impact analysis areas. However, even when discussed by vegetation type, ecological effects of fire are at best only generalized. Specific effects must be considered individually for each combination of region, climate, vegetation association, soil type, and plant or animal species (Ahlgren and Ahlgren 1960), along with the specific objectives for the site to be treated.

Prescribed burning affects soils primarily by consuming litter; organic soil layers; down, dead, and woody fuels; and vegetative cover (Wright and Bailey 1982). Fire may alter soil chemical properties, nutrient availability, postfire soil temperature, microorganism populations and their activity rates, physical properties, wettability, and erosion.

The degree to which these characteristics are affected in the short term depends on the ignition technique used; dead fuel, live fuel, organic layer, and soil moisture at the time of burning; thickness and packing of the litter layers; depth and duration of heat penetration into organic and soil layers, as well as maximum temperature attained at different depths within the profile; soil type; and soil texture. Nutrient losses from the site and postfire erosion are closely related to topography, remaining plant cover, frequency and area of bare soils, and the timing and severity of postfire precipitation events with respect to postfire litterfall and vegetative recovery. A significant storm can wash ash from the surface, removing many of the nutrients released in the ash. Gentle rains can carry some of these nutrients into the soil profile. Many of the nutrients released in ash can be taken up by rapidly growing vegetation. Net nutrient losses caused by consumption of organic matter may be counterbalanced by increased availability of nutrients formerly locked in complex organic forms that cannot be used by plants. Activity of decomposing and nitrogen-fixing organisms may also change, further affecting the postfire nutrient balance.

Changes in soil chemical properties, including soil nutrients, caused by burning usually include an increase in soluble nitrogen, phosphorus, potassium, sulfur, magnesium, sodium, and calcium, and an increase in soil pH, which means a decrease in soil acidity (Fuller et al. 1955, Summerfield 1976). Carbon-nitrogen ratios are reduced because of the nitrogen increase and subsequent carbon decline caused by burning (Fuller et al. 1955). Losses of nitrogen and sulfur from mineral soils can occur as a result of volatilization, but conflicting results have been reported (Wright and Bailey 1982). Very severe (high-heat) fires usually result in net soil losses of nitrogen, calcium, and magnesium (Stark 1977, De Bano and Conrad 1978). Infiltration and percolation of water also may leach these nutrients in addition to raising the pH of the soil, altering soil chemistry, and changing ground-water and surface-water quality. Soil cation-exchange capacity also may decrease after severe burns (Wright and Bailey 1982).

The percentage of nitrifying bacteria in soil that are killed depends on the depth and duration of soil heating, which varies significantly among fires. This is true for any group of soil microorganisms. Microorganism populations decline immediately after a burn (Jurgensen et al. 1979) but can quickly recover to greater than preburn numbers (Wright and Bailey 1980). Nitrifying bacteria, however, are extremely sensitive to fire over wet and dry soil and do not recover quickly after a burn (Dunn and DeBano 1977). The threshold temperature level is lower in wet soil than in dry soil, and the amount of soil heating is generally regulated through the prescription in the prescribed fire plan. Heterotrophic bacteria respond to heating in a similar manner as nitrifying bacteria, but at higher temperatures (Dunn and DeBano 1977). Fungal responses to burning are not consistent (Ahlgren and Ahlgren 1965). However, when related to metabolic processes, microbial populations are not adversely affected by prescribed burning (Wright and Bollen 1961, Jorgensen and Hodges 1971, Summerfield 1976).

The effect of fire on soils is closely related to the burn severity and the heat pulse to the soil, which is the result of the combustion of all fuels during flaming, glowing, and smoldering combustion. Significant amounts of deep soil heating occur only if there is long-duration burning in thick organic layers or accumulations of dead woody debris. Moisture content of thick organic layers, large-diameter dead fuels, and soil are critical determinants of the depth of heat penetration because wet fuels do not burn and moist soils limit the depth of soil heating (Frandsen and Ryan 1986). There is a close relationship between fireline intensity (the rate of heat released per foot of fire line during flaming combustion) and flame length. However, there is little relationship between the heat released during flaming combustion and soil heating. Most of the heat from flames rises and does not heat the soil. A high intensity fire with long flame lengths will cause little soil heating except at the immediate surface if subsurface fuels and soils are moist.

Studies generally agree that prescribed burning causes no appreciable change in soil mineral fractions (Beaton 1959, Summerfield 1976), although the heat of very severe fires may render a soil structureless and alter porosity and infiltration rates (Ralston and Hatchell 1971). However, a fire this severe is not likely to be staged in the vegetation types in the EIS area under prescribed conditions. Measurable changes in aggregation and permeability in soil surface layers also have been reported (Scott and Burgy 1956). Soil aggregate stability is maintained by vegetation cover protection (Tate 1987).

Depending on the severity and duration of a fire, some moderately permeable soils may develop resistance to wetting through the distillation of organic compounds (Wells et al. 1979, Wright and Bailey 1982, Holechek et al. 1989). Water-repellent layers are most common in shrub communities on dry, sandy soils (DeBano et al. 1976), but also occur in forest soils (Zwolinski and Ehrenreich 1967).

Vegetative cover, in addition to supplying organic material to the soil, also provides a structural shield to the ground surface. Removal of vegetation and litter exposes mineral soil and subjects the surface to raindrop impact, increasing overland flow and subsequent soil loss (Wright and Bailey 1982, Holechek et al. 1989). Soil creep and debris flow also can occur after soil is exposed (Wright and Bailey 1982).

The most important factors determining whether significant amounts of postfire erosion will occur are the amount of residual vegetation and organic matter remaining, the rate and amount of vegetative recovery, the timing of the vegetative recovery with respect to season and severity of precipitation events, and slope. In forested sites, litterfall of scorched conifer needles can significantly cover the soil. When planning a prescribed fire on erodible soils, these effects can be mitigated by prescribing the fuel and organic layer moisture, thus minimizing the amount of organic layer removal; timing the fire so that vegetative recovery begins soon after; and leaving unburned areas of vegetation.

Sagebrush

Most chemical and soils effects in sagebrush as a result of prescribed fire are limited to the areas beneath sagebrush plants where most of the litter has been consumed because these are the only areas where high enough temperatures are generated to cause heating of associated soils to any significant depth. The major concern when burning is the postfire possibility of wind and water erosion (Summerfield 1976). The likelihood of erosion increases with slope and the length of time that the area remains sparsely vegetated. Wind erosion of significant amounts of topsoil is possible. For this reason, treatment planning must consider the timing of the burn with regard to the growing period of native vegetation and the time when any planted species might germinate and grow, as well as the seasonal occurrence of high winds or major precipitation events. Most soils in the sagebrush-grass areas are derived from basalt, and soil texture varies from loamy to clayey, although extensive areas have soils derived from rhyolite, loess, lacustrine, alluvium, and limestone (Wright et al. 1979).

In general, studies indicate that the chemical and physical properties of soil on sagebrush sites are affected as discussed in the introduction of prescribed burning effects on soils. Organic matter, pH, and nitrogen may be increased in soil surface layers (Summerfield 1976), but Blaisdell (1953) reported no pH change after sagebrush-grass burning. Burning sagebrush and leaf mulch may produce water repellency in soils under sagebrush plants (Salik et al. 1973). Although burning while the soil and mulch are cool and damp will reduce or eliminate this potential (Salik et al. 1973), pure stands of sagebrush may burn extremely hot (Wright and Bailey 1982).

Desert Shrub

Desert soils are not characterized by large amounts of organic matter, and desert fires do not seem to substantially alter soil characteristics (Patten and Cave 1984). As in all shrub communities, the presence of woody fuel is the most important factor contributing to high soil temperatures. Although heat produced by the comsumption of highly flammable shrubs like blackbrush will alter soil properties directly under the plants (Callison et al. 1985), Patten and Cave (1984) reported no changes in soil water repellency nor temperatures after fire. However, soil stability problems may result from loss of perennial plant cover (Callison et al. 1985, Patten and Cave 1984).

Southwestern Shrubsteppe

Because of site variation and moisture conditions, there are few apparent trends on the effects of burning on semidesert grasslands on soil chemical properties (Uechert et al. 1978). Nitrogen losses in grassland fuels can be considerable, but total nitrogen losses for mineral soils after burning appear negligible (Sharrow and Wright 1977a). Increased soil temperatures after burning may enhance soil organic matter breakdown (Sharrow and Wright 1977b) and act to accelerate the plant uptake and availability of certain essential nutrients contained in organic matter complexes. Physical properties were unaffected on heavy clay soils after a desert grass-shrub fire (Uechert et al. 1978). Although soil-water infiltration has been shown to be two to three times higher with litter cover than bare soil (Bentner and Anderson 1943), burning had little effect on infiltration in a mesquite/tobosa-grass community (Uechert et al. 1978). Soil losses from prescribed burning generally are small in these communities (Wright and Bailey 1982, Uechert et al. 1978).

Chaparral-Mountain Shrub

Chaparral soils are relatively infertile and lower in nutrients than soils developed under grasslands (De Bano et al. 1977). Because organic matter is consumed, the soil chemical properties changed by burning are pH, cation-exchange capacity, nitrogen, sulfur, divalent ions, and potassium. After burning, pH in chaparral soils generally is higher, but the increase may be slight (Sampson 1944). After fires, nutrient availability in the surface soils increases as does cation-exchange capacity, although some portion of total nitrogen and potassium are lost by volatilization and other mechanisms (De Bano et al. 1977, Dunn and De Bano 1977, De Bano and Conrad 1978). Fire in chaparral can improve soil conditions by recycling nutrients and removing allelopathic chemicals that inhibit seed germination. Nitrifying and heterotrophic bacteria in chaparral soils are sensitive to fire and can be killed at temperatures of 100° and 210° C (212° F and 410° F), respectively, depending on soil moisture conditions (Dunn and De Bano 1977). Fungi are not consistent in their response to fire (Dunn and De Bano 1977).

Physical properties of soil, such as aggregation, also are affected by the organic matter consumed during a fire, reduced water movement, aeration, and increased bulk density (De Bano et al. 1977). Brushfires in chaparral could further decrease infiltration by producing a water-repellent soil layer, although this effect can be mitigated through the choice of a prescribed fire prescription and soil moisture regime when burning. Soil movement following burning in chaparral communities usually is positively related to fire severity, slope, and postfire precipitation patterns (Wright and Bailey 1982). Potential erosion loss would vary with vegetation reestablishment, steepness of slope, storm intensity, and storm duration.

Pinyon-Juniper

Soil properties affected by burning on pinyon-juniper communities include reduced infiltration rates (Buckhouse and Gifford 1976a) and increased amounts of phosphorus, potassium, nitrogen, and carbon for the first year following debris pile burns (Gifford 1981). Overland flow from burned areas contained greater amounts of potassium and phosphorus than from unburned areas (Buckhouse and Gifford 1976b). Broadcast burning of chained and/or manually cut juniper is the best way to manage the site to prevent rapid takeover by small residual surviving juniper.

Burning of pinyon-juniper slash piles may be detrimental in some situations because soils may be sterilized by the concentrated heat, resulting in nutrient losses and declines in watershed quality (Everett and Clary 1985); however, in some cases, burning may be the only safe way to remove the slash piles. Leaving pinyon-juniper slash material in place, rather than concentrating slash in piles, will reduce the potential for adverse impacts to the soils caused by localization of soil heating beneath fuel piles, as well as limit additional soil compaction caused by machinery used to pile or windrow the debris. Slash material burned in this fashion also releases nutrients such as nitrogen and phosphorous to the soil for immediate seedling uptake. Prescribed burning of a site several years after trees are chained or manually cut increases the length of the effective treatment because it kills residual trees or newly established tree seedlings. Additionally, the burning of windrowed slash eliminates visual conflicts, reduces survival of young or rooted juniper and pinyon trees, and eliminates habitat for rodents and rabbits (which may increase seeding survival and establishment). Removal of shrubs and trees from pinyon-juniper communities by fire generally does not affect erosion. The treatment of shrubs and trees in pinyon-juniper communities by prescribed burning, in conjunction with good management practices, should not significantly affect the rate of soil erosion. Burning of cabled or manually cut juniper 3 years post-treatment reduced the fire hazard and killed residual trees and new juniper seedlings in central Oregon and also resulted in decreased erosion because of the release of existing understory plants and establishment of new plants, which caused a significant increase in protective vegetative cover over the watershed in comparison to the unburned area (Lent 1989).

Plains Grasslands

Burning in plains grassland communities is a widespread practice. The removal of litter and soil organic matter has similar effects on soil aggregation and infiltration as in other regions. Excessive litter accumulations may reduce microorganism activity (Wright and Bailey 1982) and nitrification; nitrogen-fixation and ammonification are increased by pH and the increased concentration of electrolytes after burning. Soil losses after burning on grasslands should be minimal because the grassland sod root systems and rhizomes remain in place, thereby facilitating rapid vegetation recovery and limiting the possibility of erosion.

Mountain/Plateau Grasslands

The impacts of prescribed burning in mountain/plateau grassland communities are similar to those of the plains grasslands. As such, the prescribed burning of these grasslands also may indirectly affect the soil through removal of litter and soil organic matter. Severe (high-temperature) burns on dry sites (such as the drier grasslands of the Colorado Plateau) may form a water-repellent layer in the soil (USDA 1988). This direct impact to soil infiltration rates typically is avoided by the burn prescription (program design), which evaluates the various parameters that control the burn conditions (fuel loading, fuel moisture content, and soil moisture conditions) and authorizes the burn to proceed only when field conditions are conducive for a successful and effective burn. Like the plains grasslands, soil losses after burning on mountain/plateau grasslands should be minimal because the grassland sod root systems and rhizomes remain in place, thereby facilitating rapid vegetation recovery and limiting the possibility of erosion.

Coniferous/Deciduous Forest

The effect of burning on forest soils is closely related to the varying fire severities (temperatures) that are possible. Burning consumes organic matter on top of the soil and may consume some of that in the soil surface (Fowells and Stephenson 1933), although prescribed burning can be conducted to minimize duff removal (Fuller et al. 1955) and heat penetration into soil. Organic matter reduction is correlated to the reduction in total nitrogen on the forest floor; however, nitrogen accumulation occurs in the 0-to-2-inch soil layer (Wells et al. 1979). Phosphorous, potassium, calcium, and magnesium may increase in the 0-to-2-inch layer of forest soils post-burn (Wells et al. 1979), although Cambell et al. (1977) reported lower potassium levels in soil of burned areas than in unburned control plots. Prescribed burning apparently does not alter soil microorganism populations to the extent that soil metabolic processes would be impaired (Jorgensen and Hodges 1971); rather, the increase of soil temperatures could enhance soil metabolic processes by causing increased rates of nutrient cycling and increased nitrogen availability because of greater activity of decomposing and nitrogen-fixing bacteria.

Severe burning generally occurs only when levels of moisture in fuel, duff, and soil are low. In most cases prescribed fire would not be done under these circumstances. The main influence of severe burning on forest soil physical properties is to decrease soil permeability to water; light burning only slightly affects the physical soil properties (Fuller et al. 1955). If consumption of heavy fuels such as forest slash occurs, fires may decrease soil aggregates and porosity and increase bulk density for up to 4 years (Holechek et al. 1989). Also, some forest soils may develop a temporary resistance to wetting (Holechek et al. 1989), on sites where soil heating was concentrated beneath burning accumulations of heavy fuels. Temporary increases in overland water flow and erosion may result where severe fires denude soil cover and change soil physical properties (Hendricks and Johnson undated, Holechek et al. 1989). Dry ravel, the gravity-induced movement of soil particles, can increase after a fire, with the amount critically related to the steepness of slope, the amount of vegetative and organic cover remaining, and the rate of vegetation recovery (B. Clark, pers. comm. 1989). However, BLM-prescribed fire plans are written with prescriptions that mitigate these negative effects, primarily by burning forested areas under moisture regimes that ensure the maintenance of residual organic cover and/or result in fairly rapid vegetative recovery.

Chemical Methods

Most of the proposed herbicides are liquid formulations that are applied onto the foliage of the targeted vegetation, although soil also may be a major receptor for these chemicals, because whether applied aerially or by truck-mounted and backpack units, some of the applied herbicide is deposited onto the soil. Granular formulations release the herbicide into the soil plant root zone with subsequent chemical uptake and absorption by the targeted plants. Removal of solid stands of vegetation by chemical treatment may result in short-term, insignificant increases in surface erosion that would diminish as vegetation reoccupies the treated site. The speed of site revegetation and the plant composition of the new vegetation would depend on the persistence and selectivity of the herbicide used. Table 3-3 gives a general description of vegetation susceptibility to herbicides.

Although herbicides would not alter a soil's physical properties, there may be indirect effects on soil microorganisms. Depending on the application rate and the soil environment, herbicides can either stimulate or inhibit soil organisms. When herbicide-treated vegetation decomposes, the resulting pulse of organic matter to the soil can support increased populations of microorganisms. Soil microorganisms can metabolize herbicides and often are reported to be responsible for herbicide decomposition (Norris and Moore 1981). However, certain herbicides may inhibit microorganism growth or may produce more toxic effects and increase microorganism mortality rates.

Potential adverse impacts on soils from the use of herbicides primarily are related to possible toxic effects on soil organisms or changes in the community composition of these organisms. Many herbicides bind strongly to soils, thus making them unavailable to soil microbes. Only herbicides that are dissolved in water can be absorbed by microbes and thus impart toxic effects. Those herbicides that are soluble and are not strongly adsorbed to soil will be most available to bacteria. For example, 2,4-D, picloram, and hexazinone are likely to be available, while sulfometuron methyl and triclopyr are minimally soluble and glyphosate is strongly bound to soil, thus making them unavailable to bacteria. Conclusive data on this topic is lacking. Because the use of herbicides does not directly impact the surficial organic layer of the soil structure, this treatment method will not be evaluated on an analysis region basis.

AQUATIC RESOURCES

Ground water is used extensively in the West as a domestic water supply ranging from 90 percent of the population in Arizona, Idaho, Nevada, and New Mexico to less than 50 percent in Colorado, Oklahoma, and Oregon. These water sources vary in depth and aerial extent, and it is not uncommon for BLM lands to be above or near them.

Recent ground water studies have shown a greater number of water supplies to be contaminated with pesticides. Generally, shallower supplies are at greater risk than deeper ones. Contaminants have been shown to include a number of insecticides and herbicides. It is generally recognized that these pesticide contaminants originate from agricultural lands and poor application practices.

The EPA in response to the concern for ground water contamination developed a rating system to delineate ground-water contamination vulnerability. This system, known as DRASTIC (Aller et al. 1985), has been used nationwide and uses factors of depth to water, net recharge, aquifer media, soil media, topography, impact to unsaturated zone, and gross hydraulic conductivity to identify potential vulnerability areas. Figure 2-8 shows those vulnerability areas for the EIS area. Most of the areas in Figure 2-8 are in the low and moderate vulnerability category. However, the information presented in EPA (1987) was constructed with very general data and may over or underestimate vulnerability. For example, areas having higher than normal recharge patterns would not be identified. Such areas would have a higher vulnerability than is shown on Figure 2-8. Care should be taken to make sure the DRASTIC system is applied properly at the site-treatment level.

Manual Methods

Manual methods should not increase peak flows because plant water use would be little affected. Stream nutrients and sediment loads would not increase because litter and duff would be left intact and revegetation would not be suppressed.

Mechanical Methods

The impacts of mechanical treatments on aquatic resources depend on their impacts on soil hydrologic characteristics (discussed under Soils). The following discussion draws on the Soils section impacts analysis to analyze impacts of mechanical treatments to surface- and ground-water resources.

When mechanical treatments greatly reduce vegetation cover, particularly on sloping sites, general and storm runoff of precipitation will increase, with a concomitant increase in overall stream volume and peak volume. Loss of vegetation cover results in erosion potential and subsequent increases in stream sediment loads. Mechanical methods can greatly increase erosion on steep slopes but in practice are most frequently used on gentle slopes where the erosion hazard is limited. When treatments improve the soil infiltration rates, particularly on the more level sites, percolation of precipitation to ground-water sources will increase.

Surface Water

Treatments aimed at reducing woody species and increasing herbaceous species greatly reduce water runoff and erosion and improve soil stability (Branson et al. 1981). Mechanical treatment that allows growth of desirable vegetation with greater cover than before treatment generally should result in decreased runoff and erosion. Therefore, the hydrologic response to control may be greatly dependent on the success of revegetation.

Temporary loss of vegetation cover from mechanical treatments may result in increased erosion and resulting sedimentation from high-intensity summer thunderstorms; however, erosion from winter snow and gentle rainfall will be limited (Lusby 1979). Recovery of infiltration rates and sediment control generally occurs with time, with interim losses depending on the speed of natural or artificial revegetation and replacement of vegetation cover.

Conversion from woody to herbaceous vegetation would not necessarily increase water yields from rangeland watersheds; however, if vegetation cover is maintained by existent and seeded herbaceous plants after mechanical disturbance, runoff and erosion should decrease. Revegetation to replace lost cover would be recommended to reduce potential erosion on windrowed sites. Increased surface roughness after mechanical disturbance may decrease runoff and erosion of some noncrusting soils as long as vegetation cover is not greatly reduced. Coarse-textured soils of many rangelands would continue to maintain similar infiltration and sediment production rates after mechanical treatment (Brown et al. 1985).

Effects vary regionally, as discussed in the Soils section. For example, mechanical methods to control pinyon-juniper are used to increase water yield from selected watersheds (Blackburn 1983). Cabling juniper can increase the amount of total dissolved solids, cations, and anions in runoff compared to untreated lands. Chaining and windrowing pinyon-juniper debris may reduce infiltration and increase streamflow, while double-chaining and leaving debris in place may not affect infiltration and water yield (Gifford 1975, Williams et al. 1972).

Most of the precipitation on sagebrush rangelands falls in the winter as snow or gentle rains and would not be expected to greatly erode disturbed soils. On a watershed scale, disk plowing of sagebrush and drill seeding beardless bluebunch wheatgrass in Colorado quadrupled herbaceous forage production and decreased summer runoff and annual sediment yield by 75 and 80 percent, respectively (Lusby 1979).

Ground Water

Soil aggregate stability, which is necessary for high infiltration rates, is maintained by vegetation cover, which protects the aggregates from raindrop impact, and by soil organic matter, which holds aggregates together (Tate 1987). Direct impacts associated with mechanical disturbance will be highly site- and treatment-specific, but negative effects would be most expected on fine-textured soils lacking organic matter and soil structure with low aggregate stability and a tendency to form a crust. Lack of soil aggregation results in formation of a surface crust, especially on fine-textured soils, which reduces infiltration. Mechanical treatment of crusted soils could be expected to increase infiltration for a while, but effects would be highly dependent on vegetation response after treatment (Cary and Evans 1974).

Coarse-textured soils with initially high infiltration rates and clayey soils with low infiltration rates generally would be expected to change little after direct mechanical disturbance. However, if the mechanical treatment creates furrows or pits to hold water or breaks up a shallow soil layer of limited permeability, infiltration may increase (Brown et al. 1985). The soil disturbance produced by grubbing, bulldozing, and chaining/cabling may be extensive; however, pits created by plant extraction and debris left in place may trap water and limit runoff and erosion (Blackburn 1983).

Effects on ground-water recharge vary regionally by the specific mechanical treatment used and by the success of revegetation, as discussed in the section on Soils. For example, rootplowing of creosotebush sites on southwestern shrubsteppe, coarse-textured Arizona soils reduced runoff by increasing surface roughness and detention storage and by increasing plant cover (Tromble 1976). Rootplowing of creosotebush and seeding grasses in New Mexico resulted in less vegetation cover and lower infiltration rates than in untreated areas (Tromble 1980). Infiltration rates increased on rootplowed areas when seeded grass cover had sufficient time to increase. Infiltration rates decreased after plowing sagebrush and unsuccessfully seeding perennial grass in Nevada (Gifford 1972).

Biological Methods

Studies of grazing effects on water resources usually are limited to discussions of general grazing practices. Grazing may minimally increase stream concentrations of nutrients. Livestock with access to streams may increase bacteria in the water, which should drop to base levels within a few days after livestock removal. Mitigation (stock tanks, alternative water supplies) are intended to prevent water contamination and streambank damage, so risks of contamination of public water supplies should be minimal.

Heavy grazing may increase stormflows by reducing soil infiltration capacity and plant water use. Heavy grazing likely would reduce soil infiltration capacity by 50 to 90 percent (Blackburn 1983, Patric and Helvey 1986, Wood et al. 1987), but infiltration would remain sufficient to absorb all but the most intense rainstorms (Patric and Helvey 1986). Light-to-moderate grazing would reduce infiltration by less than 50 percent. These impacts will vary

according to site, depending on size and the grazing management techniques used. In general, impacts should be negligible on smaller sites conducted under careful BLM management plans, and the overall impacts from this method should be negligible.

The potential for impact from biological treatment by insects or pathogens is lower than that from grazing. The vegetative cover of the treatment area will remain constant, decreasing effects on runoff and infiltration. In most cases, the target plants would remain standing, although weakened or unable to reproduce.

Prescribed Burning

Prescribed fire may increase stream nutrients, stormflows, and sediment loads. In general, the amount of increase depends on fire severity.

Slash burns may produce minor increases in concentrations of some nitrogen compounds and cations; however, drinking-water standards should not be exceeded even by severe burns. Underburns and grassland burns would have no significant effect on nutrients.

Moderate slash burns may increase stormflow volumes and peaks to streams by reducing the water used by remaining vegetation. Severe burns would cause greater increases by exposing mineral soil and promoting surface runoff.

Underburns and grassland burns would be light to moderate. Underburns would not affect water quality, and grassland burns would affect it for only a few weeks until grass regrows. These burns would not significantly affect stormflows.

Chemical Methods

Herbicides applied to the land may enter surface or ground water. Herbicide use also may produce minor increases in stream nutrients, stormflows, and sediment yields.

Surface Water Impacts

Entry of herbicides into surface water is discussed in the risk assessment (Appendix E). Herbicides may enter streams during treatment through accidental direct application or drift, or after treatment through surface or subsurface runoff. To pollute the water, they must be present in the water at concentrations high enough to impair water quality at a point of use.

Direct application of herbicides to surface water may occur if aircraft accidentally fly over streams, lakes, or ponds during pesticide application. Risks of direct application are highest for right-of-way maintenance because the linear flight path may cross many streams. Peak concentrations would depend mostly on the application rate and degree of overflight; these have commonly been 2.1 to 2.4 parts per million (ppm) in field studies where overflight was substantial (USDA 1988).

Drift of herbicides into surface water would depend on the application method, existence of buffer zones, and weather. Drift potential would be least for ground-applied pellets and greatest for aerially applied fine droplets. Buffer zones reduce drift impacts on sensitive areas, while wind increases drift impacts. Peak concentrations from aerial spraying of fine droplets with 50- to 70-foot buffer zones commonly have been 0.130 to 0.148 ppm in field studies (USDA 1988). Mitigation requires buffers of 100 feet (aerial), 25 feet (ground-vehicle), and 10 feet (ground-hand), and nozzles producing large (200-micron) droplets, so peak concentrations in surface waters from herbicide drift should rarely exceed 0.05 ppm (Appendix E). Large droplets do not travel as far as small droplets, so the larger the droplet size, the less extensive the drift during application.

After treatment, herbicides may enter streams by subsurface flow or by movement in ephemeral channels. Key factors that would affect peak concentration include the presence of buffers, storm size, herbicide properties, soil properties, and downstream mixing and dilution.

Impacts would be minimal in perennial and intermittent streams because they are protected by 10-foot (ground-hand), 25-foot (ground-vehicle), and 100-foot (aerial) buffers. Herbicides applied along these streams must move through the buffer in subsurface flow and are subject to dilution and mixing in transit. Impacts may occur, however, in ephemeral streams, which often do not have buffers. Herbicides applied directly to them usually are picked up in streamflow by the first storm large enough to create flow in the channels.

Large storms rarely produce high concentrations because herbicides are diluted by large water volumes, while small storms may not produce enough flow to move herbicides into streams. Therefore, intermediate storms often produce higher concentrations of pesticides in streams relative to the other two situations because the resulting streamflow is sufficient to mobilize the herbicides but not large enough to substantially dilute the material.

The amount of herbicide available for movement from the site of application with surface or infiltrating water will be determined, in part, by the herbicide's persistence. Herbicide persistence is usually expressed in terms of "half-life." This is the typical length of time needed for one-half of the total amount applied to break down to substances that

are no longer of toxicological concern. While a herbicide's soil half-life in practice is influenced by local conditions such as soil type and climate, it is useful for describing the relative rates at which various herbicides are broken down in the soil. Table 3-6 gives field half-lives for the 19 herbicides proposed for use in the EIS. Half lives are divided into three categories, "non-persistent" herbicides are defined as having a typical soil half-life of less than 30 days, "moderately persistent" herbicides as having a typical soil half-life of 30 to 100 days, and "persistent" herbicides as having a typical soil half-life of more than 100 days. These values are considered most representative of the values reported in the literature, as the rate of degradation by natural processes is not only dependent on herbicide chemistry, but also environmental factors. Sunlight, temperature, soil and water pH, microbial activity and other soil characteristics may effect the breakdown of herbicides. Soil organic matter, and soil properties such as moisture, temperature, aeration, and pH all affect microbial degradation. Microbial activity increases in soils that are warm, and moist with a neutral pH. In addition to microbial action, chemical degradation of herbicides can occur by reaction with water, oxygen or other chemicals in the soil. As soil pH becomes extremely acidic or alkaline, microbial activity usually decreases, however these conditions may favor rapid chemical degradation. Sunlight can also be an important pathway of herbicide degradation. Some of the factors that affect herbicide photodegradation include the intensity and spectrum of the sunlight, length of exposure, the application site or method, and the properties of the herbicide that make it more or less stable when exposed to sunlight.

In addition to degradation, these herbicides may be unavailable for movement with surface or infiltrating water due to volatilization and plant uptake. Volatilization is the loss of herbicide vapors to the atmosphere from plant and soil surfaces. The rate of volatilization is determined by the herbicide's vapor pressure and how strongly it is adsorbed. Vapor pressures for the herbicides proposed for use in the EIS are given in Table 3-6. The higher the vapor pressure the greater the potential for loss due to volatilization. Also, higher temperature usually results in increased volatilization. The degree of plant uptake is partially determined by the herbicide's water solubility. The more water soluble a herbicide is, the greater the possibility for plant uptake. In addition, for those herbicides applied to foliage, interception of the spray by foliage will reduce the amount of herbicide reaching the soil surface where it is available for movement with surface or infiltrating water. Foliar residues are usually more susceptible to photodegradation and volatilization. By contrast, those herbicides applied directly to the soil surface have a greater possibility of movement with surface or infiltrating water.

Soil adsorption is also important in determining mobility in surface or infiltrating water. Adsorption of a herbicide varies with the properties of the chemical, as well as the soil's texture (relative proportions of sand, silt, and clay), moisture level, and amount of organic matter. Soils high in organic matter or clay tend to be the most adsorptive, and sandy soils low in organic matter least adsorptive. Therefore, the higher the organic matter content of the soil, the more adsorptive the soil and the less likely the herbicide is to move from the point of application. The degree of herbicide adsorption is often represented by the ratio of the amount of herbicide in the soil water to the amount adsorbed to the soil. This ratio is called the adsorption coefficient or Kd. The degree of adsorption depends on both the herbicide and the soil properties. The Kd for a herbicide is soil specific and will vary with soil texture and organic matter content. Another herbicide adsorption coefficient, which is less soil specific is called the Koc. The Koc is the Kd divided by the percent of organic carbon in the soil, a major component of soil organic matter. The higher the value for Kd or Koc, the greater the adsorption. Water solubility and Koc values for herbicides proposed for use in the EIS are given in Table 3-6.

Groundwater contamination occurs when herbicides move with the infiltrating water through the soil profile to the water table. The closer the water table is to the surface, the more likely that it may become contaminated. In some situations, herbicides that are tightly bound to the soil may only move a few inches from the point of application regardless of the amount of infiltrating water, whereas in other situations herbicides have been shown to move many feet. Herbicides that are highly water soluble, relatively persistent, and not readily adsorbed by soil particles (low Kd or Kos) have the greatest potential for movement. In addition, relatively level sandy soils low in organic matter are the most vulnerable to groundwater contamination due to their lower adsorptive capacity and higher infiltration rates. Soil characteristics and environmental conditions vary widely over the proposed treatment areas in the EIS. Herbicide properties which determine the likelihood of movement with infiltrating water and a leaching index based upon the work of Goss (1988) are given in Table 3-6. The leaching index is a relative ranking of the 19 herbicides based upon their chemical properties only. The higher the value, the greater the potential that the herbicides will move through the soil profile with infiltrating water. This ranking suggests that imazapyr, clopyralid, picloram, tebuthiuron, and metsulfuron methyl have the greatest potential for movement, with glyphosate being the least mobile. Prediction of actual amounts of these herbicides that may reach groundwater must also consider the method and rate of application, as well as the soil characteristics and other environmental and climactic factors described above.

Table 3-6

Chemical and Environmental Properties of Herbicides Used on Rangeland

Herbicides	Soil Half-life days (range)[1]	Solubility mg/1	Koc ml/g	Leaching Index[2]	Vapor Pressure mm Hg
Non Persistent (half-life of less than 30 days)					
2,4-D acid	10 (2-16)	890	20	2.70	8.0x10-6
2,4-D esters	10 (2-41)	1E[3]	1000E	1.00	
Dicamba salt	14 (3-35)	400000	2	4.24	0
Mefluidide	2 (2)	180			1.0x10-4
Sulfometuron methyl	20 (20)	70(pH7)[4]	78(pH7)	2.74	6.0x10-16
Moderately Persistent (half-life of 30 to 100 days)					
Atrazine	60 (18-120)	33	100	3.56	2.9x10-7
Bromocil acid	60 (60-360)	700	32	4.44	3.1x10-7
Clopyralid amine salt	30 (12-70)	300000E	6	5.46	0
Diuron	90 (30-328)	42	480	2.58	6.9x10-8
Glyphosate amine salt	47 (21-60)	900000E	24000E	-0.64	0
Hexazinone	90 (30-180)	3300	54	4.43	2.0x10-7
Imazapyr acid	90 (90-712)	11000	100E	6.45	less than 1x10-8
Picloram salt	90 (20-277)	200000E	16	5.46	0
Simazine	60 (11-149)	6	130	3.49	2.2x10-8
Triclopyr ester	46 (30-90)	23	780	1.84	1.3x10-6
Persistent (half-life of more than 100 days)					
Chlorsulfuron	160 (28-160)	7000(pH7)	300(pH7)	3.36	4.6x10-6
Metsulfuron-methyl	120 (14-180)	9500(pH7)	35(pH7)	5.11	2.5x10-12
Tebuthiuron	360 (13-450)	2500	80	5.36	2.0x10-6

[1] Most representative half-life value and range of reported values (Wauchope et al. 1991).

[2] Relative ranking of leaching potential using the equation L.I. = Log(Half-Life)*(4-Log(Koc)), (Goss 1988).

[3] E-estimate, probable error: solubility: less than 3X, Koc: 3-5X, or wide range in reported values (Wauchope et al. 1991).

[4] Solubility and Koc are a function pH, values given are for pH7.

Surface runoff can carry herbicides mixed in water or bound to eroding soil. The severity of herbicide runoff depends on several factors, many of which influence the rate of water infiltration into the soil. These include the grade or slope of an area, the texture and moisture content of the soil, the amount and timing of rainfall, and the presence of vegetation or plant residues. These conditions vary widely over the proposed treatment areas in the EIS. Herbicide properties which determine the likelihood of movement with surface water are given in Table 3-6. For conditions resulting in moderate to high infiltration rates, the likelihood that the herbicide will remain close to the soil surface may determine availability for movement with surface runoff. Under these conditions, glyphosate, diuron, triclopyr, and chlorsulfuron have the greatest potential to be available for movement with runoff. However, the low water solubility of chlorsulfuron, and diuron would indicate that the majority of the runoff loss would be associated with soil erosion. Without soil erosion, little runoff loss would be expected. For conditions where infiltration is low, those herbicides with high water solubility and low Koc values would be most likely to move with surface runoff. These include dicamba, clopyralid, and picloram, as well as the relatively persistent metsulfuron-methyl. As with infiltration, prediction of actual amounts of these herbicides in runoff must consider the method and rate of application, as well as the soil characteristics and other environmental and climactic factors described above.

Herbicide movement in ephemeral channels is little affected by herbicide mobility because buffers are seldom used and herbicides may be applied directly to the channel. Herbicides can be mobilized in solution or with sediment. Peak concentrations in field studies have ranged from 0.18 to 0.55 ppm (USDA 1988).

Dilution and mixing sharply reduce herbicide concentrations downstream through water inflow and turbulence. As watershed size doubles, peak herbicide concentration should drop to one-quarter of its initial level (Neary et al. 1983). For example, a peak concentration of 0.4 ppm in an unprotected ephemeral stream with a 10-acre watershed will likely drop to 0.04 ppm by the time it reaches a perennial stream with a 50-acre watershed.

Mitigation requires buffer zones along perennial and intermittent streams. Mixing and dilution sharply reduce concentrations delivered by ephemeral streams. Normal application of herbicides at typical rates may produce sporadic peak concentrations of some herbicides in small, headwater perennial streams. These concentrations may range up to 0.04 to 0.05 ppm in some cases. Even applying EPA's most stringent drinking-water standard (0.1 ppm for 2,4-D) across the board, these concentrations pose minimal risks to water quality for public health or aquatic biota. Risks from accidental direct application may be high on some corridor maintenance projects treated aerially. Because picloram affects many vegetable crops at concentrations as low as 0.010 ppm (Baur et al. 1972), it should be used with care near water used for irrigation.

Ground-Water Impacts

After treatment, herbicides may move through the soil and into underlying ground-water aquifers by leaching. To pollute ground water, they must then move laterally at concentrations high enough to impair water quality at a point of use. Key factors affecting peak concentration are herbicide properties, soil, depth to water table, and distance to the point of use. Applied at typical rates, herbicides should never occur in ground-water supplies at concentrations exceeding a small fraction of EPA's most stringent drinking-water standards.

Herbicide mobility and persistence greatly affect potential for leaching. Mobility depends on solubility and adsorption; persistence depends on degradation mode and rate. As discussed earlier, the most potentially mobile herbicides are 2,4-D, picloram, and, to a lesser extent, hexazinone, and the most persistent ones are tebuthiuron, picloram, and glyphosate. Mobility and persistence properties suggest that herbicides with at least a moderate leaching potential include 2,4-D, dicamba, hexazinone, imazapyr, picloram, and tebuthiuron.

Herbicides move most easily through sands, which are the most porous soils and have the least adsorption potential. The potential for ground-water contamination increases as the depth to the water table and the distance to the point of use decrease.

Field studies of herbicides applied at typical rates have shown that sulfometuron methyl and triclopyr did not leach to shallow ground water, and that hexazinone reached peaks of less than 0.024 ppm. Applied at typical rates, picloram concentrations in shallow ground water should be less than 0.002 ppm.

FISH AND WILDLIFE

Wildlife species depend directly on vegetation for habitat, so any change in the vegetation of a particular plant community is likely to affect the wildlife species associated with that community. Any change in community vegetation structure or composition is likely to be favorable to certain animal species and unfavorable to others (Maser and Thomas 1983). The key to understanding the effects of vegetation manipulation on wildlife involves an understanding of the vegetation structure, production, flowering, and fruiting of the community; these characteristics relate to seasonal cover and food requirements for particular animal species and predators dependent on them. These characteristics also respond to a particular vegetation manipulation.

Plant communities on many western rangelands are no longer pristine and therefore do not support pristine populations of wildlife species. Many rangeland plant communities have alien herbaceous weeds or a higher ratio of woody to herbaceous perennial vegetation than under pristine conditions. These vegetation conditions may favor certain wildlife species, such as the chukar partridge, which depends on the alien annual grass, cheatgrass, for food (Weaver and Haskell 1967), or they may disfavor other species, such as the pronghorn antelope, which require mixed-plant communities, rather than those plant communities dominated by a few woody or herbaceous species (Yoakum 1975). In general, the greater the diversity of the plant community, the greater the diversity of the associated animal community (Gysel and Lyon 1980).

Therefore, any change in vegetation community structure or composition affects resident fish and wildlife populations. The effects of vegetation manipulation on wildlife depend on vegetation structure, production, and phenology of the community. Because these characteristics relate to seasonal cover and food requirements for particular animal species—and the predators that depend on them—and because these characteristics respond differently to different vegetation manipulations, effects on fish and wildlife from vegetation management would be both positive and negative, depending on the species affected and the type of treatment used. Treatments that reduce runoff and sedimentation would

have positive benefits for fish and aquatic wildlife, and there would be shifts or changes in forage and habitat for wildlife, depending on the species. For example, an improvement in deer winter range could result. Vegetation treatments can negatively affect aquatic habitats by causing changes in food supply, water temperature, water chemistry, and bottom composition. Elimination of multistoried vegetation along streambanks would increase water temperature and reduce the supply of invertebrates used as a food source for fish. However, no treatments will eliminate this streamside vegetation to any significant degree, and in general an improvement in riparian vegetation is expected as a result of upland treatments improving watershed conditions. Expected results are an increase in streamside vegetation, a cooling of water temperatures, and an improvement in the depth and quality of fish habitat, including invertebrate populations and other food sources.

Studies determining the effects of vegetation manipulations on wildlife in riparian areas were not found in the literature, but impacts on wildlife species will be identified in individual environmental analyses, when site-specific proposals are selected.

There are data gaps in the understanding of the effects of specific land treatments on the multitude of wildlife species. Therefore, it is very important to monitor the specific impacts of a particular treatment on the wildlife community being impacted. These monitoring studies should be accomplished in cooperation with the state wildlife management agency and the results made available to other interested agencies and personnel.

Manual Methods

Manual methods have the advantage of being highly selective, thus avoiding the potential loss of valuable habitats (Vallentine 1971). Manual methods, however, could negatively affect those wildlife species that depend on the target plants for food or cover. Although this method of vegetation control may open a young forest canopy, it may not benefit larger mammals because the unremoved material can impede movement. These obstacles may restrict deer and elk from using any increases in available forage. Smaller animals also may be affected, particularly birds or small mammals nesting in or at the base of individual target plants. Conversely, accumulated material resulting from manual control could provide cover for smaller mammals and birds, therefore increasing their use of an area. The impacts created by manual treatments should be relatively insignificant. The vegetation communities are generally so expansive, and manual labor so expensive, that the potential for significant changes is not likely.

Sagebrush, Desert Shrub, Southwestern Shrubsteppe, Plains Grasslands, and Mountain/Plateau Grasslands

These vegetation communities are generally very expansive. Any impacts of manual treatments would be very site-specific and insignificant on a program-wide evaluation. There would be no significant overall impact to wildlife from manual vegetation treatments in these communities, any site-specific impacts will be evaluated in the site-specific environmental analysis. Larger scale treatments would generally have the same wildlife impacts as mechanical methods.

Chaparral-Mountain Shrub, Pinyon-Juniper, and Coniferous/Deciduous Forests

These vegetation communities are often densely vegetated and may be more practically and economically treated by manual methods. If areas treated by manual methods are limited to small areas, most impacts would be beneficial through increase in habitat diversity in a densely vegetated environment. Size, shape, and spacing of the openings will determine the degree of benefits to wildlife. Excessive or poorly planned thinning of coniferous forests can be detrimental to elk, mule deer, black bear, and other wildlife through loss of thermal and escape cover. Conversely, a well-planned thinning that considers size, spacing, and topography can be beneficial by improving the food-cover relationship. Larger sized treatments would have impacts similar to mechanical treatments.

Mechanical Methods

Mechanical treatments have traditionally been applied most frequently to decrease woody plant cover and increase production of grasses (see discussions of effects of treatments on vegetation). Some species are favored by these conversions, and some are disfavored. Conversion of sagebrush-dominated rangelands in Oregon to more open grasslands is associated with a substantial increase in the pronghorn antelope population (Yoakum 1975), but has been detrimental to sage grouse populations (Call and Maser 1985). Much of the literature on the effects of range vegetation manipulations on wildlife considers treatments designed to increase grass production.

Fish are also in a unique situation. Improperly applied treatment could result in increased siltation

from mechanical treatments which could result in loss or degradation of spawning substrate. However, once mitigation is applied, the treatment would be beneficial to the condition of the watershed and ultimately improve habitat for fish.

Mechanical methods can result in soil compaction, damaging the subterranean habitat used by certain burrowing animals. As with manual methods, accumulated material can hinder movement of the larger mammals, but removal of this material would reduce potential habitat niches for many small mammals and birds. Habitat shifts or changes as a result of downed material could last for as long as two decades, assuming normal decomposition rates. It is important to note that mechanical treatments can be selected and structured to increase and decrease other vegetation components and thus favor or disfavor different wildlife species. These treatments can be considered tools for wildlife habitat management when vegetation responses and habitat requirements are understood. Accordingly, determinations on whether particular vegetation treatments will increase or decrease wildlife populations must be made on a site-specific basis, taking into account specific vegetation and animal information. In general, mechanical treatments can be beneficial for wildlife if the treatment areas are arranged in strips and patches and if methods are selected that increase browse and forage availability. Also, negative impacts can be lessened if the period of treatment avoids the bird nesting season and other critical seasons when loss of cover would be critical to wildlife, for example, during critical reproductive periods and prior to severe winter weather conditions. The following discussion presents examples of the relatively limited research on wildlife responses to vegetation manipulations through mechanical treatments.

Sagebrush

Although few wild vertebrates require sagebrush habitats, sagebrush is so widespread that it is a major habitat type in the West (McEwen and DeWeese 1987). The quality of sagebrush habitat for wildlife can vary tremendously and can be a complex situation for analysis. Sagebrush habitat may be critical in certain situations for sage grouse and for wintering big game species. In areas of limited rainfall and forage production the thermal cover provided by sagebrush may be critical to deer and other wildlife survival (W. A. Molini, pers. comm. 1990). Any treatments on critical habitat must receive careful site-specific analysis to avoid significant negative impacts. The sagebrush situation also is complicated by the apparent increase in density and the expanded acreage resulting from human-caused disturbances, creating an "unnatural" existing situation before treatment. Conflicts may arise between maintaining the existing wildlife community and recreating a "natural" wildlife community. As a general rule, negative impacts will be minimized if sagebrush is not removed in large, expansive blocks and if treatment areas are composites of small 40- to 60-acre units with irregular outlines and configurations. In sage grouse habitat, the width of removal areas should not exceed 100 feet.

The design of control units in the sagebrush region is critical to the consequences of the action. The cumulative effect of past control activities must be considered in assessing current and future actions. These two considerations are extremely critical in manipulations of sage brush in sage grouse habitats. The size of control units, the juxtaposition of remaining sagebrush stands, the comparative densities and height of the sagebrush, and the juxtaposition of other habitat components (drinking water and wet meadows) are all significant to the potential impacts. Site-specific analysis and project design are crucial to the success of sagebrush treatment for wildlife. If sagebrush is properly controlled and the end result is an increased diversity and production of a variety of perennial grasses, and a variety of forbs and shrubs, wildlife diversity and abundance also should increase. However, sagebrush control in Nevada by root plowing generally has resulted in the loss of all brush species, including desirable browse species (W. A. Molini, pers. comm. 1990). This would result in a significant adverse impact to big game and other brush-related species and should be considered for mitigation where loss of brush species creates significant adverse impacts. This points out the critical value of the site-specific analysis and in-depth consideration of all ecological values before implementing a proposed treatment.

Desert Shrub

Plant control by mechanical means in desert shrubland must usually be followed by revegetation, which is normally unsuccessful because of low and erratic precipitation. Plant control treatments run the risk of reducing perennial plant cover and increasing weedy annual cover. These possible vegetation changes are expected to also negatively affect indigenous wildlife species. Vegetation manipulation of desert shrubland is generally not recommended.

Southwestern Shrubsteppe

Mechanical treatments have most frequently been applied to reduce the cover of woody species, such as mesquite, that have invaded the semidesert grassland. Increasing structural diversity of vegetation by controlling shrubs and increasing understory species in strips and patches should increase bird diver-

sity and density. Mesquite control that selectively leaves areas important for browse and cover will be much more beneficial for deer than extensive control projects (Severson and Medina 1983).

Rootplowing woody species and seeding perennial grasses increased cotton rat populations in Texas (Guthery et al. 1979). However, sites converted to African lovegrasses in Arizona had much lower diversity and abundance of grasshoppers, rodents, and birds than native grassland sites (Bock et al. 1986). Only sites that lack native grass cover will be considered as candidates for lovegrass seeding after woody plant control, and only if lovegrass already occurs within the watershed.

Smith (1984) compared bird use of undisturbed, crushed, and tebuthiuron-treated creosotebush in Arizona. Black-throated and Brewer's sparrows foraged opportunistically, while verdins avoided crushed plots and vesper sparrows avoided control plots. Mechanical treatments opened up small areas in the creosotebush community, which were used as nesting sites for Cassin's sparrows and feeding sites for grass-eating flocks. Large-scale conversion to grasslands may be detrimental to Gambel's quail, but beneficial to scaled quail, and improve the potential for reintroduction of aplomado falcon.

McCormick (1975) compared small game use of areas invaded by mesquite with areas where mesquite had been controlled to 16 to 100 trees per acre. Both areas supported a native perennial grass and forb understory. Use by doves, quail, and cottontail rabbits was less on the mesquite-controlled areas, while jackrabbit use was similar on controlled and uncontrolled areas. McCormick recommended that mesquite be controlled only where density exceeds 100 trees per acre and advised limited control of small, dense mesquite stands in the drainage areas (100 to 324 trees per acre) to maintain a habitat for these small game species. Germano (1978) compared use by various animals on mesquite-dominated areas, mesquite-free areas, and mesquite woodland with clearings. Mesquite with clearings produced more observations of jackrabbits, antelope, quail, and lizards than the mesquite-free areas. Mesquite-dominated areas had more use by jackrabbits and lizards than did the mesquite-free areas. Total clearing of mesquite may reduce vegetation structural diversity and use by wildlife.

Chaparral-Mountain Shrub

Deer is the only species from the chaparral type of plant community that has been studied extensively (Cable 1975). Deer populations are low in dense brush stands with little understory. Opening up dense stands would generally be beneficial for wildlife; however, some brush should be left uncleared to provide escape cover for deer. In Arizona, deer spent much less time on chaparral cleared by rootplowing and herbicide spraying than in untreated areas (Urness 1974). However, in this study, deer used the cleared areas mainly for feeding. Foraging efficiency was probably high because of high herbaceous plant production compared to uncleared areas. Shrub control treatments resulted in a loss of cover but also brought about a compensating increase in forage production for deer in chaparral. Urness (1974) recommended leaving some brush, clearing less than 50 percent of the area, and clearing in strips no wider than 437 yards. Where brush is so dense that understory forage is lacking, deer and elk use can be increased by brush control.

Mechanical treatments have been used to induce sprouting of brush species and to increase forage availability for deer and elk. However, shrubs intolerant of these treatments may produce less forage after treatment. When chaparral species are controlled by mechanical means, wildlife use should increase as understory production increases and suitable areas are left intact to provide cover.

Pinyon-Juniper

Pinyon-juniper areas with limited understory diversity are usually treated by mechanical means to increase grasses, shrubs, and forbs. Estimating wildlife populations response to these treatments—compared with their behavior in undisturbed areas—is difficult and usually depends on the vegetation diversity before and after treatment in relation to that of undisturbed stands. As in sagebrush removal, negative impacts from pinyon-juniper removal would be minimized by treating patches, resulting in a mosaic of thermal and hiding cover and open foraging areas. For example, chaining pinyon-juniper in Colorado greatly reduced tree cover and did not change shrub cover, but it increased cover of grasses and forbs (Sedwick and Ryder 1987). However, only one of the most common species of breeding birds (chipping sparrow) used the chained plots, while seven other common species used the undisturbed plots. Chaining reduced bird use and species diversity. Foliage- and timber-searching, aerial-foraging, foliage-nesting, and cavity-nesting birds infrequently used the chained plots, while ground-searching and ground-nesting species regularly used them. Evans (1988) suggested that negative effects of chaining on cavity-nesting birds can be minimized by leaving cavity trees near the edge of the treatment zone. Old growth pinyon and/or juniper stands may offer unique and valuable wildlife habitats, adding to the variety within pinyon and juniper stands. When planning site-specific treatments, these old growth communities should be recommended to be left standing as islands and edge communities to the chained or treated areas.

Chaining pinyon-juniper has generally increased small mammal use (Baker and Frischknecht 1973, Sedwick and Ryder 1987). The increased populations of species such as deer mice and chipmunks are thought to be a result of increased grass and forb cover and associated abundance of seeds and arthropods (Sedwick and Ryder 1987). Although black-tailed jackrabbits and desert cottontail may prefer cabled pinyon-juniper over untreated areas (Howard et al. 1987), cottontail rabbits may benefit by leaving a density of 68 to 80 downed trees or living shrubs per acre (Kundaeli and Reynolds 1972). Smith and Urness (1984) also emphasized the importance of leaving downed trees onsite for cover for small mammals. Conversion of juniper woodland-shrubland to wheatgrasses may have negative effects on hawks by reducing cover and the abundance of jackrabbits as well as nesting sites (Howard and Wolfe 1976).

Removal of pinyon and ponderosa pine, as well as juniper and oak, decreased sightings of Merriam's turkey in Arizona (Scott and Boeker 1977). This study recommended strip clearing of trees and retention of mature ponderosa pine for roosting sites to minimize effects on turkey populations.

Mechanical control of pinyon and juniper may increase its use by mule deer for a number of years (Tueller 1976). However, deer use of treated areas is encouraged by the proximity of undisturbed areas for cover (Tausch 1973). Terrel (1973) observed increased deer use in undisturbed areas adjacent to chained areas. Short et al. (1977) found that extensive tree clearing decreased elk and mule deer use, while patch cutting increased use. Evans (1988) suggested irregular chainings to create more edge and patch clearing as ways to increase habitat diversity and wildlife use of pinyon-juniper control projects.

Plains Grasslands

Mechanical treatments most frequently have been applied to reduce cover of woody species, such as mesquite. Increasing structural diversity of vegetation by controlling shrubs and increasing understory species in strips and patches should increase bird diversity and density. Mesquite-dominated rangelands are considered important habitat for mule deer and white-tailed deer. Deer will use these cleared areas less frequently because of reduced food and cover.

Mountain/Plateau Grasslands

The few studies that consider effects of plant control on wildlife on mountain/plateau grasslands are concerned with sage grouse, gophers, or prairie dogs. Mechanical treatments most likely would affect animal density in these areas because of reduced cover and forage.

Coniferous/Deciduous Forests

The literature on effects to wildlife species in this area is sparse; mechanical control will lower the seral stage of the undergrowth in the treatment area, and may affect the biodiversity in the vicinity. When used in these forest-habitat types, this method can improve seed germination, thereby increasing available forage. Pretreatment analysis should include the effects of the proposed treatment on old growth forest habitats and spotted owl habitat.

Biological Methods

BLM may consider using grazing animals, insects, and pathogens as biological methods of vegetation treatment. Typical grazing, as discussed in much of the available literature, generates many impacts on wildlife populations. These impacts may be direct, when wildlife and livestock share food preferences, or indirect, when livestock cause some modification, such as vegetation changes, to the ecosystem. These possible negative effects can be avoided by using grazing systems for biological control that help to increase or maintain wildlife diversity.

Grazing animals may have many effects on wildlife. In riparian areas, grazing can affect songbirds by changing the vegetation composition of the community, thus changing the songbird community because of different habitat requirements. Waterfowl may be similarly affected, especially during breeding and nesting periods. Fish populations may be affected because of changes in stream shading and resulting changes in water temperature. In non-riparian areas, larger game animals may compete directly with livestock for forage. Elk and cattle tend to show the same forage preferences, as do sheep, pronghorn antelope, and deer. Deer use browse, which may be an important forage for cattle in some areas. Biological control using livestock should take these factors into consideration when planning a grazing system (Humphrey 1962).

There also are many positive effects on wildlife from biological control by grazing animals. Small mammal diversity will increase up to a point with the use of grazing as a biological treatment method (Dwyer et al. 1984). Rotation grazing systems have been cited as beneficial for certain wildlife species. The sandhill crane (Grus canadensis) prefers the larger insect population found in grazed areas, and deer (Odocileus) are attracted to the grass regrowth in a recently grazed pasture. In sagebrush regions, cattle grazing can increase the production of bitterbush, a shrub that is palatable to deer. Grazing cattle

or sheep in the spring or early summer can increase winter browse for elk (Vallentine 1980). These effects may become noticeable on larger areas being treated by grazing animals.

The impacts of biological treatment by insects and pathogens on wildlife will generally be slight. In most cases, the target plants will remain standing, although weakened or unable to reproduce, thus reducing noticeable and immediate effects. Over time, the composition of the plant community may change, as the native plants regain their competitive edge, possibly improving wildlife habitat. Any insects or pathogens used for general vegetation treatment should be carefully tested for host specificity, thus reducing or eliminating possible negative effects on native vegetation that may be important in wildlife habitats.

Prescribed Burning

Many prescribed fires are staged with the principal objective of modifying some aspect of the vegetation for wildlife. Yet, changes in forage quality and quantity, interspersion of new feeding areas with areas providing cover, and rejuvenation of decadent browse plants are all reasons for burning for wildlife. Changes in vegetation structure and dispersion of burned areas are key factors when planning prescribed fires for wildlife purposes.

Many different wildlife (vertebrate) responses to fires have been reported. Fire effects on wildlife vary with: (1) animal species complex, (2) mosaic of habitat types, (3) size and shape of fire-created mosaic, (4) fire intensity, (5) fire duration, (6) fire frequency, (7) fire location, (8) fire shape, (9) fire extent, (10) season of burn, (11) rate of vegetation recovery, (12) species that recover, (13) change in vegetation structure, (14) fuels, (15) sites, and (16) soils. In addition, all the other factors that alter fire effects on vegetation and soils will influence wildlife responses to burning.

In general, fire affects wildlife by direct killing, alteration of immediate postfire environments, and postfire successional influences on habitat (Lyon et al. 1978). Direct killing of vertebrates by prescribed burning is rare (Lyon et al. 1978). For those species that cannot flee a burn, the most exposed habitat sites are dry, exposed slopes, hollow logs with a lot of exposed wood, burrows less than 5 inches deep, lower branches of trees and shrubs, and poorly insulated underground/ground nesting areas (Lawrence 1966, as cited by Peek 1986). Effects of prescribed burning on ground cover depends on fire severity: low severity fires on wet sites would remove less cover than high severity fires on dry sites. Escaped prescribed burns may accidentally destroy riparian habitats and impact aquatic resources, causing losses of wildlife through exposure, total loss of habitat, and through increased sedimentation of the aquatic habitat caused by unchecked overland flow and destabilized stream channels.

Fire mainly affects wildlife through habitat alteration (Wright 1974a). Fire may have a positive effect on wildlife habitats by creating habitat diversity, by recreating lost or degraded habitats for indigenous species, and by allowing for the reintroduction of extirpated species when habitat degradation was significant to their extinction. Immediate postfire conditions raise light penetration and temperatures on and immediately above and below soil surfaces and can reduce soil moisture (Lyon et al. 1978). Burning of cover and destruction of trees, shrubs, and forage modify habitat structure (Lyon et al. 1978, Peek 1986). The loss of small ground cover and charring of larger branches and logs (with diameters greater than 3 inches) can negatively affect small animals and birds. Early, vigorous vegetation growth immediately after a fire alters feeding and nesting behaviors (Lyon et al. 1978). Postfire plant and animal succession effects creating seral and climax mosaics in habitat cannot be generalized in their effects on wildlife (Lyon et al. 1978, Peek 1986). Negative impacts can be lessened if the period of treatment avoids the bird nesting season and other critical seasons when loss of cover would be critical to wildlife; for example, during critical reproductive periods and prior to severe winter weather conditions.

Sagebrush

No significant changes in small mammal species were observed for 1-year postburn in sagebrush-grassland (Frenzel 1979, as cited by Starkey 1985), but shrews and other species with narrow niches require patches of unburned vegetation to sustain populations, although total small mammal numbers may not be altered (McGee 1982). Habitat changes induced by fire may temporarily decrease the number and diversity of small mammals in sagebrush vegetation (Klebenow and Beall 1977). By increasing habitat diversity, associated bird communities may be increased by burning (Starkey 1985). Low fire frequencies may be useful in maintaining productive habitat for sage grouse (Peek 1986). Large intense fires affect other bird species, such as yellowthroat, yellow-breasted chat, Traill's flycatcher, and yellow-billed cuckoo, because they require dense shrub cover (McAdoo and Klebenow 1978). Conversely, sparrow species require relatively less shrub cover (McAdoo and Klebenow 1978). Because chucker partridge rely heavily on cheatgrass, fire could conceivably be used to improve the habitat for this species (Wright and Bailey 1982). Prescribed burning in these types also may improve the habitat for higher numbers of sheep, pronghorn antelope, and mule deer (Klebenow 1985). Fire suppression has favored the expansion of mule deer populations in some sage-

brush areas because of the increased forage or cover (Crouch 1974). In areas of limited rainfall and forage production the thermal cover provided by sagebrush may be critical to deer and other wildlife survival (W. A. Molini, pers. comm. 1990).

Desert Shrub

Plant control by prescribed burning in desert shrubland usually must be followed by revegetation, which is normally unsuccessful because of low and erratic precipitation (Jordan 1981, Blaisdell and Holmgren 1984). Plant control treatments run the risk of reducing perennial plant cover and increasing the cover of weedy annuals. These possible vegetation changes also are expected to negatively affect indigenous wildlife species. Vegetation manipulation of desert shrubland is generally not recommended.

Southwestern Shrubsteppe

Fire can play a role in changing wildlife habitat in southwestern shrubsteppe (Wagle 1981). More black-tailed jackrabbits and bird calls were observed in undisturbed and partially cleared mesquite stands than on adjacent cleared areas (Germano et al. 1983). Wright and Bailey (1982) indicated that fire in desert grasslands is harmful to Gambel's quail but beneficial to scaled quail. Renwald et al. (1978) reported that some honey mesquite trees and lotebushes should be protected during controlled burning to ensure adequate cover. However, Bock and Bock (1978) found more raptors and game birds on 1-year-old burns in sacaton grasslands. Total small mammal populations were reduced. Their study suggested that fire would benefit the wildlife of sacaton communities if mixed-age stands were maintained. In southwestern mesquite-tobosa communities, Renwald (1977) found the highest lark sparrow nesting densities in recently burned areas, and Sontiere and Bolen (1976) reported similar findings with mourning doves.

Fire suppression in desert grasslands has probably allowed mule deer and white-tailed deer to expand their range and increase numbers (Wright and Bailey 1982). Controlled burning can favor some deer food plants and maintain the mesquite-grassland edge (Severson and Medina 1983).

Chaparral-Mountain Shrub

Even though chaparral brush fires burn fast and hot, most studies indicate that little direct mortality of wildlife occurs (Howard et al. 1959, Lillywhite 1977). Controlled burning that maintains diversity and productivity of chaparral can benefit wildlife, while grass conversions reduce vertebrate fauna (Lillywhite 1977). Burning chaparral can shift rodent species from chaparral- to grassland-dominant areas (Wright and Bailey 1982). Rotational burning can greatly improve deer browse and increase deer densities in chaparral communities (Bissell 1955, Wright and Bailey 1982).

Pinyon-Juniper

While complete type conversion of pinyon-juniper sites to grassland may reduce wildlife diversity, creating a mosaic of successional stages with prescribed burning can be beneficial to wildlife (Severson and Medina 1984). Spotty burning probably would favor the greatest diversity of rodent and bird species (Wright and Bailey 1982). Fire suppression has also favored expansion of mule deer populations in some pinyon-juniper areas because of the increased forage or cover. Deer and elk use of burned pinyon-juniper areas depends on postfire successional stages (Stager and Klebenow 1987), because burning can eliminate some important deer browse species (McCulloch 1969). An important factor in the degree of use of burned pinyon-juniper habitats by deer and elk is the interspersion of burned habitats, which provide food, and unburned sites, which provide thermal and hiding cover. Old growth pinyon and/or juniper stands may offer unique and valuable wildlife habitats, adding to the variety within pinyon and juniper stands. When planning site-specific treatments, these old growth communities should be recommended to be left standing as islands and edge communities to the prescribed burning areas.

Plains Grasslands

Fire can be used to benefit some species of prairie wildlife. Dabbling ducks and sharp-tailed grouse production increased on burned grassland as compared to undisturbed grassland in North Dakota (Kirsch and Kruse 1972). Prescribed burning also improved upland plover production. Fires can be destructive to songbirds, which require shrubs for nesting (Renwald 1977). Periodic burning is desirable to maintain ideal prairie chicken habitat in tallgrass prairie, but burned areas may not be preferred habitat for sharp-tailed grouse for several years postfire (Wright and Bailey 1982).

Coniferous/Deciduous Forests

Fire effects on wildlife in coniferous forests depend on ecological relationships and animal habitat needs. Ground fires have little direct influence on tree squirrels and may even be favorable by per-

petuating ponderosa pine communities (Wright and Bailey 1982). Ground squirrels initially decreased in burned ponderosa pine communities but increased later as early successional advances were made (Lowe et al. 1978). Fire would probably adversely affect chipmunks in those communities where drier conditions prevail, but they may increase postburn on more moist sites (Lowe et al. 1978, Wright and Bailey 1982). Total bird numbers increased initially after burning in ponderosa pine communities in Arizona but fell to below prefire levels later, although some individual species responded in an opposite manner (Lowe et al. 1978).

In one study, both deer and elk decreased their use of areas immediately following a burn but quickly increased levels of use as compared to control plots. Benefits to deer and elk from fires in these types are generally related to increases in understory vegetation (Leege and Hickey 1971, Severson and Medina 1983). Burns in Douglas-fir and ponderosa pine communities improved forage palatability to mule deer (Keay and Peek 1980). Prescribed fire also can improve winter forage for mountain sheep (Hobbs and Sporwart 1984). Prescribed fire can be used to rejuvenate old aspen stands, increasing habitat for moose, elk, deer, ruffed grouse, and snowshoe hare, all of which depend on the forage or cover produced in a young aspen community (DeByle 1985).

Chemical Methods

Chemical treatments, like mechanical methods, traditionally have been applied most frequently to decrease woody plant cover and increase the production of grasses. Herbicidal control of sagebrush decreases use by sage grouse, which require high sagebrush cover for breeding and nesting (Peek 1986). The control of broadleafed woody plants, especially by selective herbicides, often results in the control of associated broadleaf forbs, both categories on plants contain species which may be important food for many different wildlife species. Near riparian areas, using chemicals to control vegetation can increase sedimentation, which can reduce or eliminate suitable spawning habitat, however, if the appropriate buffer width of existing vegetation is retained and sufficient uneffected vegetation exists within the treated area, there should be no significant erosion sedimentation occurring.

Although most documented cases consider the effects on wildlife of vegetation treatments designed to increase grass production, chemical treatments can be selected and structured to increase and decrease other vegetation components for the benefit or exclusion of different wildlife species. These treatments can be considered tools for wildlife habitat management when vegetation responses and habitat requirements are understood. Accordingly, determinations about whether particular vegetation treatments will increase or decrease wildlife populations must be made on a site-specific basis, taking into account specific information about vegetation and animals. All treatments will affect some change in the existing wildlife communities, including amphibians, reptiles, and invertebrates. These changes in the wildlife community will be analyzed in the pretreatment evaluation, and the project would not be recommended if the effects are unacceptable. The end result of the treatment should be more beneficial to wildlife in general than the community and/or populations foregone by the treatment. Special status wildlife species must receive full and detailed consideration. It is also assumed that the herbicide evaluation techniques and requirements, as approved by the regulatory and academic communities, are adequate for evaluating the impacts of herbicides to the environment, and as a land management agency we are operating within the labelling restrictions and regulations.

Aerial herbicide applications have the most significant potential for affecting wildlife. When determining the timing of herbicide applications, consideration should be given to the potential for humans to consume wildlife that have fed on herbicide-contaminated forage. The treated area could be posted to notify the public of the possible contamination, if herbicides pose any risk. Also, the effect of herbicide consumption on lactating mammals or the feeding of contaminated foods to offspring must be considered. Some negative impacts can be lessened if the period of treatment avoids the bird nesting season and other critical seasons when loss of cover would be critical to wildlife; for example, during critical reproductive periods and prior to severe winter weather conditions. Application of 2,4-D, or diesel fuel as a carrier of herbicides, will have a significant adverse impact to bird eggs, and young of any wildlife species, and should be especially avoided.

Most riparian areas are crucial habitat for wildlife and no major treatments are proposed. The primary practice will be for riparian areas to be buffered and protected from any impacts. The most significant proposed treatment is to remove exotic saltcedar through treatment of individual plants by cutting and brush painting the stump with picloram or triclopyr (Garlon 3A). This treatment should have minimal impact on non-target vegetation, although picloram can affect adjacent vegetation through root transfer. The use of diesel fuel as a carrier for triclopyr could have a significant affect on adjacent aquatic habitats if accidental spills occur.

The BLM Pest Control Handbook, H-9011-1, requires buffering of domestic waters, perennial marsh areas, important fishing and recreational waters, and/or significant fish spawning, rearing,

and migration streams. Recommended buffers are the larger of the herbicide label recommendation or 25 horizontal feet for vehicle spraying and 100 horizontal feet for aerial spraying. Additional mitigation is proposed by recommending use of helicopters for spraying adjacent to critical areas and requiring a maximum drift control nozzle (microfoil boom type) for the greatest possible control of the herbicide being applied, and avoiding applications during critical seasons for the fisheries resources. Even with these mitigations it is still possible for impacts to occur through accidental spills or other accidental unplanned events, such as major run-off events after herbicide application. To minimize impacts to fish and other aquatic wildlife, the use of amitrole, atrazine, clopyralid, dalapon, diuron, simazine, triclopyr (butoxyethyl ester only), 2,4-D, or diesel oil carriers should be very carefully regulated and applied when the treatment area is adjacent to aquatic habitats. With these mitigations, and barring accidents, no negative impacts are anticipated to the riparian, fisheries, or other aquatic resources.

Because of this short exposure and the proposed application rates, herbicides are not expected to significantly affect fish or their habitat under any alternative. However, due to the highly significant and sensitive nature of this resource, it is important to consider suggested mitigation and design features (see Chapter 1) to ensure protection of these resources from all potential impacts of vegetation treatment.

For a detailed discussion of herbicide risks to aquatic organisms, see Appendix E, which relates possible doses to documented toxic effects on aquatic organisms. The following sections contain examples illustrating how relatively limited the research is on wildlife responses to vegetation manipulations by herbicidal treatments.

Sagebrush

Although few wild vertebrates depend solely on the sagebrush analysis region, sagebrush is so widespread that it is a principal habitat type in the West (McEwen and DeWeese 1987). Herbicidal control of sagebrush reduces populations of some breeding birds, especially shrub nesters, such as Brewer's sparrow (Best 1972, Schroeder and Sturges 1975, Castrale 1982). A reduction in floral diversity associated with herbicide treatments reduces seeds for insects, which are, in turn, important food for nestlings (Best 1972). The greater the reduction of sagebrush, the greater the negative effect on shrub-nesting birds (Castrale 1982). For this reason, mechanical methods, such as chaining or railing, which only partially control sagebrush and do minimal damage to understory species, may be less detrimental to these birds than chemical treatments (McEwen and DeWeese 1987).

A mixed sagebrush ecosystem provides essential habitat for a variety of wildlife. McAdoo et al. (1986) found the greatest perching and song bird diversity in mixed sagebrush-wheatgrass communities as compared to communities dominated by either sagebrush or wheatgrass. A balanced mixture of shrub- and ground-nesting species of birds occurred in the mixed grass-shrub community, while ground and shrub nesters, respectively, were dominant in grass- and brush-only communities.

Similarly, Smith and Urness (1984) compared small mammals on sites dominated by sagebrush and those where sagebrush was cleared and wheatgrasses were dominant. Total rodent numbers and biomass were greatest where sagebrush and grass occurred together. Deer mice were more abundant in woody plant habitats, while pocket mice were equally abundant in sagebrush and grass-dominated sites.

Sagebrush also is a potential food source for some species. Although wheatgrass established after sagebrush control may furnish important winter and spring forage for mule deer (Austin and Urness 1983), sagebrush, which is more accessible when the snow is deep, is critical winter food in many areas (McAdoo and Klebenow 1979). In areas of limited rainfall and forage production the thermal cover provided by sagebrush may be critical to deer and other wildlife survival (W. A. Molini, pers. comm. 1990). Sagebrush also is important in winter for antelope (Bayless 1969). Yoakum (1975) emphasized that sagebrush conversion treatments that reduce vegetation diversity, such as spraying with herbicides, plowing, or disking, are less desirable for antelope than chaining and revegetation with a mixture of species. Yoakum noted that antelope do best on rangelands with an abundance of grass, forbs, and shrubs. Sagebrush control programs that greatly reduce sagebrush and associated forbs on critical summer and winter ranges may be detrimental to sage grouse, mule deer, white-tailed deer, and moose (Quimby 1966, Kufeld 1968).

In addition, chemical treatment of sagebrush may alter important habitat requirements. Peek (1986) reviewed the possible negative effects on sage grouse of herbicidal control of sagebrush. These upland game birds require sagebrush cover for nesting and breeding, as well as associated forbs for food, and substantial decreases in sage grouse density occur after sagebrush control. Consequently, sagebrush should not be controlled within 1.5 miles or more of sage grouse breeding complexes or along nearby riparian areas (Braun et al. 1977a).

Despite these negative impacts, chemical treatment may be beneficial for wildlife. For example, herbicidal control of sagebrush leaves the dead brush standing to serve as nesting sites for some years after treatment (Castrale 1982). Also, herbicidal con-

trol of sagebrush and the resulting increase in grass production may result in increased use by elk (Wilbert 1963). However, elk response to sagebrush control may depend on the availability of forage before and after spraying on treated and adjacent areas. Ward (1973) observed no difference in the grazing habits of elk on scattered sprayed and unsprayed areas.

Most research indicates that vegetation treatment programs should maintain a diversity of vegetation types, including sagebrush. McEwen and DeWeese (1987) emphasized the importance of vegetation diversity to wildlife in the sagebrush region. When sagebrush conversions result in increased diversity and production of grasses, forbs, and shrubs, wildlife abundance and diversity should increase. Although it is difficult to maintain mixed communities of sagebrush and other plants on some sites because of the strong competitive nature of sagebrush, vegetation diversity can be increased by expanding the edge areas of the shrub control treatment zone and by seeding mixtures of species in controlled areas. Neither sagebrush- nor grass-dominated areas are as favorable to wildlife as mixed communities. Future sagebrush conversion projects should provide for vegetation diversity to benefit wildlife.

Desert Shrub

Plant control by chemical means in desert shrubland must usually be followed by revegetation. Revegetation efforts are normally unsuccessful because of low and erratic precipitation. Plant control treatments in desert shrubland risk reducing perennial plant cover and increasing the cover of weedy annuals. Also, because these vegetation changes are expected to negatively affect indigenous wildlife species, vegetation manipulation of desert shrubland is generally not recommended.

Southwestern Shrubsteppe

Chemical treatments have most frequently been applied to reduce the cover of woody species, such as mesquite (Martin 1975). Although research has described the life history and habitat requirements of many wildlife species (for example, see literature citations in Martin and Reynolds 1973), only limited research has addressed the effects of vegetation manipulations on wildlife in southern Arizona and New Mexico. The effects of vegetation treatments on wildlife from research in Arizona and Texas is discussed here.

Expanding the structural diversity of vegetation by controlling shrubs and increasing understory species in strips and patches should increase bird diversity and density. However, such control could decrease deer use by reducing food and cover. Smith (1984) compared bird use of undisturbed, crushed, and tebuthiuron-treated creosotebush in Arizona. Black-throated and Brewer's sparrows foraged opportunistically, while verdins avoided crushed plots and vesper sparrows avoided control plots. In the creosotebush community, chemical treatments opened up small areas, which were used as nesting sites for Cassin's sparrows and feeding sites for grass-eating flocks.

McCormick (1975) compared small game use of areas invaded by mesquite with areas where mesquite had been controlled to 40 to 101 trees per acre. Both areas supported a native perennial grass and forb understory. Doves, quail, and cottontail rabbit use was less on the mesquite-controlled areas, while jackrabbit use was similar on controlled and uncontrolled areas. To maintain a habitat for these small game species, McCormick (1975) recommended controlling mesquite only where density exceeds 101 trees per acre and advised limited control of small, dense mesquite stands in the drainage areas (101 to 323 trees per acre). Germano (1978) compared use by various animals on mesquite-dominated areas, mesquite-free areas, and mesquite woodland with clearings. More jackrabbits, antelope, quail, and lizards were observed in mesquite areas with clearings than in mesquite-free areas. Jackrabbits and lizards used the mesquite-dominated areas more than mesquite-free areas. Totally clearing mesquite may reduce vegetation structural diversity and wildlife use.

As long as cover was maintained, white-tailed deer in Texas adapted to reductions in preferred browse species associated with chemical shrub control (Quinton et al. 1979). In this study, deer populations declined when cover was greatly reduced. The importance of overstory cover and understory forage for deer has led to the use of partial brush control techniques in Texas (Scifres and Koerth 1986). Woody plant regrowth on strip-treated areas increased deer use during the first winter after treatment (Tanner et al. 1978). Habitat patterning of using herbicidal strip treatments or variable herbicide rates to create areas of different wood plant mortality may benefit wildlife (Scifres and Koerth 1986). Mesquite control that selectively leaves areas important for browse and cover are likely to be much more beneficial for deer than extensive control projects (Severson and Medina 1983).

Chaparral-Mountain Shrub

The limited research on wildlife in the chaparral type of plant community has focused on deer (Cable 1975). Because deer populations are low in dense brush stands with little understory, opening these

stands is generally considered beneficial for wildlife (Cable 1975). However, leaving some brush intact is recommended to provide escape cover for deer. In Arizona, deer spent much less time on chaparral cleared by rootplowing and herbicide spraying than on untreated areas (Urness 1974). However, in this study, deer used the cleared areas mainly for feeding. Foraging efficiency was probably high because of high herbaceous plant production as compared to uncleared areas. Shrub control treatments resulted in a cover loss, but they also brought about a compensating increase in forage production for deer in chaparral. Urness (1974) recommended leaving some brush on all aspects of range management, clearing less than 50 percent of the area, and clearing in strips no wider than 437 yards. Where brush is so dense that understory forage is lacking, brush control can increase deer and elk use.

Gambel oak areas in Colorado sprayed with phenoxy herbicides had a tremendous increase in elk density as compared to unsprayed areas 2 years after treatment (Kufeld 1977). After 5 years, Gambel oak had regrown, and elk use declined to near pretreatment levels. Kufeld recommended that such areas be treated every 3 years to suppress oak and increase understory production and, consequently, elk use.

Herbicide treatments have been used to induce sprouting of brush species and to increase forage availability for deer and elk. However, shrubs intolerant of these treatments may produce less forage after treatment. Mountain shrub species in Idaho, including maple, willow, ceanothus, rockspirea, and ninebark, had limited basal sprouting after applications of phenoxy herbicides (Lyon and Mueggler 1968). Herbicidal treatments of these species to improve forage availability for deer or elk are not recommended. When chaparral species are controlled by chemical means, wildlife use should increase as understory production increases and suitable areas are left intact to provide cover.

Pinyon-Juniper

The competitive ability of pinyon and juniper trees gradually reduces shrubs, grasses, and forbs on many sites that are left undisturbed (Tausch and Tueller 1977). Using chemicals to control the trees generally increases understory production (Skousen et al. 1986, see the discussion on vegetation) and thereby may increase mule deer use. At the same time, tree control reduces cover and may decrease deer use in some cases. Severson and Medina (1983) have summarized various authors' recommendations to minimize the loss of pinyon-juniper cover for mule deer when conducting control treatments. Suggested sizes of treated areas average no more than 1/3 mile across, and no more than 20 - 50 percent of the total area, depending on the significance of the type of habitat, should be treated.

Of special concern are the effects of vegetation manipulation on bitterbrush associated with pinyon-juniper and sagebrush rangelands. On some rangelands, bitterbrush provides the bulk of mule deer forage in the fall (Austin and Urness 1983). Bitterbrush generally tolerates 2,4-D applications better than it does burning; when sagebrush is controlled by 2,4-D, its forage production may increase (Blaisdell and Mueggler 1956, Murray 1983).

Chemical control of pinyon-juniper areas is expected to have more of a negative effect on associated understory species and potentially a greater negative effect on wildlife use than mechanical methods such as chaining and cabling. Except for breeding birds, which prefer tree habitats, wildlife diversity and use can generally be maintained or increased by pinyon-juniper treatments that expand understory diversity, production, and ecotonal edges.

Plains Grasslands

Chemical treatments have most frequently been applied to reduce the cover of woody species, such as mesquite, that have invaded the plains grasslands. Increasing the structural diversity of vegetation by controlling shrubs and increasing understory species in strips and patches should expand bird diversity and density. Plains grasslands provide important habitat for the mule deer and the white-tailed deer, and clearing large areas can decrease deer use by reducing food and cover.

Meadows supporting sage grouse populations should not be treated with herbicides that control broadleafed plants because sage grouse depend on the seeds and buds for food. Applications of 2,4-D that control meadow forbs would also reduce gopher populations dependent on these forbs. However, prairie dogs on plains grasslands are able to switch their diets from forbs to grasses and maintain their populations after 2,4-D applications.

Mountain/Plateau Grasslands

The few studies that consider the effects of plant control on wildlife on mountain meadows or plains grasslands address sage grouse, gophers, or prairie dogs. Spraying 2,4-D to control iris on mountain meadows in Nevada greatly reduced dandelion and yarrow, which are important spring food for sage grouse (Eckert et al. 1973a). Total forb and dandelion production was minimal to deficient the first year of spraying but increased to adequate for existing sage grouse populations 2 years after 2,4-D applications (Eckert et al. 1973b). Meadows supporting

sage grouse populations should not be treated with herbicides that control broadleafed plants.

Chemical Treatment Risk Analysis

A risk analysis was conducted to determine the potential for adverse effects to terrestrial wildlife and aquatic organisms from using 19 herbicides and the carriers diesel oil and kerosene in BLM's vegetation treatment program. Details can be found in sections 6 to 8 of Appendix E. The risks identified are summarized here.

Risks to Terrestrial Wildlife

Risks were calculated for typical exposures to a group of representative wildlife species from rangeland and rights-of-way treatments and for worst case exposures from rights-of-way treatments. These scenarios represent the realistic and extreme exposures that might be encountered. Herbicide applications to public domain forest, recreation sites, and oil or gas drill sites would result in exposures equal to or less than those evaluated.

In general, based on the available toxicity data and on the proposed application rates, risks to wildlife are low from most of the herbicides. Estimated doses for typical rangeland and typical rights-of-way exposures result in a negligible risk from all herbicides considered, as well as diesel oil and kerosene. The application rates for several of the herbicides used on rights-of-way, coupled with extreme exposure estimates, present moderate risks to some species. However, the estimated exposures exceed the LD_{50} only under extreme assumptions for songbirds during the use of atrazine. The typical dose estimates are below the EPA risk criterion of 1/5 LD_{50} and are far below the laboratory species LD_{50} in most cases.

Even using worst case assumptions, the use of amitrole, chlorsulfuron, dalapon, glyphosate, hexazinone, imazapyr, mefluidide, metsulfuron methyl, picloram, sulfometuron methyl, diesel oil, or kerosene is not expected to pose unacceptable risks to terrestrial wildlife. The use of atrazine on rights-of-way presents a moderate risk of adverse effects to large birds, small mammals, and terrestrial amphibians for extreme exposures. Extreme exposures to songbirds result in a significant risk. Bromacil, clopyralid, and dicamba result in moderate risks to songbirds under extreme rights-of-way assumptions.

2,4-D presents moderate risks for the extreme rights-of-way scenario to songbirds, larger birds, small mammals, and terrestrial amphibians. Extreme rights-of-way exposures of diuron present moderate risks for songbirds, small mammals, and terrestrial amphibians. Extreme rights-of-way exposures to simazine result in moderate risks for songbirds and small mammals. Extreme rights-of-way exposures to tebuthiuron and triclopyr result in moderate risks to small mammals.

Risks to Aquatic Organisms

Risks were evaluated for representative aquatic species from exposure to herbicides that drift offsite from typical aerial rangeland and right-of-way applications. Risks were also estimated for an accidental direct spray of a pond and an accidental helicopter jettison of its entire load of herbicide mix into a pond. Risks were calculated for four aquatic species on which toxicity data were generally available for the herbicides. Trout were chosen to represent cold water fish, bluegills to represent warm water fish, and Daphnia (a water flea) to represent aquatic invertebrates. Risks to fathead minnows also were evaluated because toxicity information was generally available on that species.

According to risk calculations for realistic (typical) exposures, risks to aquatic species are low for all herbicides proposed for use. The only risk identified in typical cases is a moderate risk posed by the use of kerosene as an herbicide carrier. Use of appropriate buffer strips along bodies of water and avoidance of spraying on windy days would reduce this risk. No adverse effects are expected on the aquatic ecosystem as a whole. Risks from accidental direct spray of a water body or an accidental jettison of herbicide mixture into a water body are significant, but the probability of either event is low.

Drift Onto a Pond at Typical Rangeland Application Rates

In this scenario, the only risk identified is a moderate risk to trout from the use of kerosene as a carrier for 2,4-D.

Drift Onto a Pond at Typical Rights-of-Way Application Rates

In this scenario, kerosene presents a moderate risk to trout.

Accidental Direct Spray of Pond at the Highest Application Rate

This accident scenario presents risks to aquatic species from several herbicides. There would be moderate risks to bluegills from diuron and simazine, to Daphnia from dalapon, to trout and fathead minnows from atrazine, and to fathead minnows and Daphnia from 2,4-D. Significant risks were identified for Daphnia from amitrole, atrazine, and clopyralid;

for bluegills from 2,4-D; for trout and Daphnia from diuron; for trout, fathead minnows, and Daphnia from simazine; and for trout, bluegills, and pink shrimp from diesel oil.

Helicopter Jettison of 80 Gallons of Mix Into Pond

There are either moderate or significant risks to all species from most of the herbicides from a helicopter jettison into a pond. However, the probability of this type of accident occurring is extremely low.

To summarize, no direct toxic effects to either wildlife or aquatic species are expected from the use of any of the proposed herbicides. Risks to terrestrial and aquatic wildlife species from herbicides will be greater when higher application rates are used, as is generally the case on utility rights-of-way and oil and gas drill sites. Effects by analysis region depend on the extent to which this method is used in the region and the presence or absence of species that may be affected. For example, the treatment of a coniferous forest may affect forest-dwelling mammals and birds, which are likely to be present in relatively large numbers, while the treatment of a sagebrush region would have an almost insignificant potential for risk to aquatic species. Nonetheless, the risk assessment performed for this program found that the chemical risks to wildlife and aquatic species would be low to negligible, with no likely effect to larger animals. The complete assessment is included as a table in Appendix E.

CULTURAL RESOURCES

Before authorizing vegetation treatment actions that could affect cultural resources, cultural properties eligible for inclusion in the National Register of Historic Places will be identified and considered through the process outlined in the National Historic Preservation Act of 1966 and implemented in 36 CFR 800 and the BLM 8100 Manual series. In many States, specific procedures for considering cultural resources have been adapted to local needs by Programmatic Agreements among BLM, the State Historic Preservation Officer, and the Advisory Council on Historic Preservation. These agreements will control how possible effects on cultural resources will be assessed and mitigated.

Historically, there have been direct conflicts between vegetation treatment and traditional lifeway values. For example, mechanical removal of pinyon-juniper woodlands decreases the availability of pinyon nuts for traditional gathering. The list of Target Plant Species (Appendix I) does contain plants such as amaranth, sunflower, cholla, and pinyon pine that were significant to traditional peoples in prehistoric times and either remain significant (i.e. pinyon) or could remain significant in maintaining contemporary traditional lifeways. To the extent that traditional lifeway values are associated with or embodied in properties or other definite locations (BLM 1988e), possible impacts to them can be considered in the same consultation process as used for other cultural resources.

Specific impacts to known and undiscovered cultural resources are similar. Surface-disturbing activities also affect cultural resources and may destroy spatial context as well as individual artifacts features and structures. Cultural properties consisting only of surface manifestations would be destroyed or severely affected during surface-disturbing activities. Organic chemical contamination can make radiometric dating samples unusable and can affect other chemical analyses.

Manual Methods

In addition to general surface disturbance that could disrupt spatial context, mulching with organic materials would complicate radiometric dating, and the use of hard-edged tools may physically damage artifacts. Workers may illegally collect projectile points and other significant artifacts or vandalize cultural resources in other ways.

It is difficult to predict the impacts of manual treatment methods on traditional lifeway values. Given that manual methods are highly selective in their application, it will be possible to avoid specific plants that are associated with traditional lifeways. However, given that these methods may be applied several times a year and/or at specific times to be effective, there may be a direct conflict between the methods and traditional religious practices and/or plant gathering. Also, the specific plants targeted for treatment may be the same as those identified as essential to maintaining traditional lifeways.

Mechanical Methods

Tilling, roller chopping, and blading could damage both surface and subsurface artifacts and disrupt the relative positions of cultural materials. Exposing these sites may also increase the possibility of artifact theft.

Historically, mechanical methods for vegetation treatment have posed significant threats to traditional lifeway values that involve maintaining traditional food sources or access to medicinal and sacred plants. For example, removal of pinyon-juniper woodlands significantly reduces the availability of pinyon nuts for traditional harvest. Thus,

as with other methods, the impact of mechanical methods will vary directly with the extent to which plants important to maintaining traditional lifeways are the target plants for treatment or are associated with treatment plants.

Biological Methods

Biological control using grazing animals may damage surface artifacts and disrupt the relative positions of cultural materials; however, site-specific investigations would decrease this possibility. Because of the agents' small size and host-specific action, biological control using insects or pathogens is not likely to affect cultural resources.

Biological control methods will impact traditional lifeway values to the extent that targeted treatment species are essential to maintaining a traditional lifeway and that the specific method involves ground disturbance and/or landscape alteration. Increased grazing will have a greater potential to impact traditional lifeways than will the use of insects and pathogens. Plant specific biological methods, such as insects or pathogens, that are not directed toward traditional lifeway plants are highly selective and will not be likely to impact traditional lifeway values.

Prescribed Burning

The effect of prescribed burning on cultural resources depends on the location of the resource with respect to the ground surface, the proximity to fuels that could provide a source of heat, the material from which artifacts are made, and the temperature to which artifacts are exposed. Threshold temperatures for damage to cultural artifacts manufactured from different materials, such as ceramic or stone, vary significantly.

Surface or near-surface cultural materials may be damaged, destroyed, or remain essentially unaffected by prescribed burning, depending on the temperatures reached and the duration of exposure to that temperature. Wooden structures or wooden parts of stone or adobe structures are susceptible to fire. Combustible artifacts lying directly on the ground surface could be destroyed. The ability to date noncombustible surface artifacts may be adversely affected if exposed to specific high temperatures. Subsurface materials are usually affected by fire only where significant amounts of soil heating occur (where dry accumulations of dead woody fuel or duff layers are consumed). Prescribed fires in areas of cultural significance would not be ignited under conditions dry enough to cause significant subsurface heating. Subsurface cultural resources are generally more subject to harm from construction of firelines around planned fire boundaries than from the fire itself.

The heat, smoke, and soot from prescribed burning can also damage cultural resources, especially prehistoric rock art, by causing spalling which physically destroys the resource or by obscuring the surface of the resource with smoke and soot. Smoke and soot can damage cultural resources, by either increasing chemical deterioration or obscuring carvings and painted motifs.

As with other methods, the impact of prescribed burning will vary directly with the extent to which plants important to maintaining traditional lifeways are the target plants for treatment or are associated with treatment plants.

Chemical Methods

It is unlikely that cultural artifacts protected by soil or plant cover would be adversely affected by chemical treatments. The effect of herbicide treatments on cultural resources depends on the method of herbicide application and the herbicide type used.

Standing wall masonry structures, rock art panels, organic materials, and other types of cultural resources can be impacted by chemical treatments to the extent that the chemical used alters the chemistry of the application site and/or obscures or alters the surface of the application site. Impacts can also occur depending on the amount of surface disturbance created in developing and maintaining landing facilities for aerial applications and the extent of ground vehicle use.

Chemicals may affect the surface of exposed artifacts, but they can be removed. Organic solvents used to remove herbicide formulations with diesel oil or kerosene as carriers (2,4-D and triclopyr) may contaminate the soil in a site and seep into the subsurface portions of artifacts. These organic substances could interfere with the Carbon 14 dating of the sites.

As with other methods, the impact of chemical treatment will vary directly with the extent to which plants important to maintaining traditional lifeways are the target plants for treatment or are associated with treatment plants. Chemical treatment could also impact traditional lifeways, and pose a possible health threat, through residues left on plants used as traditional foods or for ceremonial purposes.

RECREATIONAL AND VISUAL RESOURCES

Recreation is described in BLM's Public Land Statistics (BLM 1987f) as being land based, water based, or snow and ice based. BLM's recreation

inventory focuses on resource-dependent activities, such as hunting, fishing, sightseeing, water sports, winter sports, off-road vehicle use, and other specialized activities that are dependent on natural and cultural features found on public lands (BLM 1987h). Less than 1 percent of the total acreage considered in this EIS consists of intensively managed, developed recreation areas. In those areas the goals of vegetation treatments include maintaining the appearance of the area and protecting visitors from adverse effects from contact with noxious weeds and target species; therefore, the adverse effects on recreation areas are not likely to be significant. However, recreation on BLM lands in areas other than intensively managed, developed recreation areas and sites is likely to be affected. For example, chaining of pinyon-juniper or a prescribed burn over a large area would adversely affect recreation activities such as hunting or birdwatching because of displacement of game and nongame wildlife species.

In addition to suppressing the growth of noxious weeds, such as thistles, ragweed, and poison ivy, which in turn decreases the exposure of recreation visitors to thorns, burrs, pollen, poisons, and other plant irritants, vegetation treatment projects provide opportunities for ecologic study and research, and environmental education and interpretation. These opportunities are especially increased in or near high-use areas.

Impacts to recreational resources would vary by treatment method. Some treatment methods would be much less objectionable to the recreationist than others. A hiker or backpacker, for example, would likely bypass a prescribed burn area altogether while continuing to use a trail passing through a mowed or mulched area.

Public lands have many different visual values. Visual values are identified through the Visual Resource Management (VRM) inventory and are grouped into four visual resource inventory classes, which represent the relative value of the visual resources. Classes I & II are the most valued, Class III is moderately valued, and Class IV is least valued. The criteria for determining the classes are scenic quality, sensitivity level, and distance zone. Landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications are used in determining an area's scenic quality (BLM 1986).

An adverse visual impact is any modification in land forms, water bodies, or vegetation, or any introduction of structures that disrupt negatively the visual character of the landscape and the harmony of the basic elements (that is, form, line, color, and texture) (BLM 1984e).

Where areas are treated by methods that could significantly change visual contrast (quality), short-term adverse impacts on visual resources would occur. However, based on standard operating procedures and long range plans, the long-term impacts would be beneficial. The intensity of the impact would depend on the treatment method and the area where it was implemented. Most of the land considered for the vegetation treatment program is Class IV; therefore, the impacts that might occur from any of the treatment methods would not be as distinct as in a Class I or II area. Factors that effect the degree of visual contrast are: distance, angle of observation, length of time in view, relative size or scale, season of use, light conditions, recovery time, atmosphere conditions and motion.

Manual Methods

Manual treatment methods of cutting, clearing, and pruning plants would have no adverse impact on recreational areas because these methods are used in areas that are difficult to reach by vehicle or in sensitive areas in which care would be taken to avoid disrupting the habitat. Manual treatment methods are species selective, so undesirable plants may be removed without killing desirable ones.

Of all the treatment methods, manual treatment methods would have the least adverse effect on visual resources because they would be used to treat small areas and to control specific species without disturbing surrounding vegetation. Because these methods are used on a small scale, the visual effects would likely be apparent only at close range.

Mechanical Methods

Mechanical methods could have adverse and beneficial effects. Heavy machinery could disrupt the area, breaking limbs and exposing soil, but mowing might improve the appearance of some sites and make them more pleasurable to visit. Mechanical treatments could make some areas more desirable for recreation activities; for example, clearing brush around a lake could make it more accessible for fishing.

Mechanical methods such as chaining and tilling disrupt the land surface and expose the soil to view. Using these methods on flat terrain, for example, in the sagebrush region, would cause less visual impact than using the methods on steeper areas, such as the pinyon-juniper region, because more area is visible as the land becomes steeper. In the long term, the regrowth of more aesthetically desirable vegetation may prove to be a beneficial impact. Mowing could have a beneficial effect when used to control unsightly vegetation along rights-of-way and in recreation areas.

Biological Methods

The use of biological treatment methods is not expected to have a great effect on recreation resources. The benefit of using insects or pathogens would be the control of very specific undesirable plant species without disturbing desirable vegetation or disrupting the land. Backpackers and campers using rangeland where livestock graze may experience some negative impacts where the livestock have grazed.

Biological treatment methods should have only minimal visual impacts. The sight of animals on rangeland is common and expected; however, an overgrazed area could be visually undesirable. The visual impacts of biological treatments with insects and pathogens should be negligible because they are very target specific and not widely used.

Prescribed Burning

Prescribed burning affects air quality and could be a problem for developed recreation sites and dispersed recreation. The effects of prescribed burning on human health is discussed in Impacts on Human Health. It is likely that visitation to a prescribed burn area would decline drastically or cease altogether in the short term. In the long term, however, visitation could increase because prescribed burning has the highest potential for habitat improvement. The use of fire to create more of the "edge effect" is unparalleled by any other treatment method. The edge effect refers to the richness of flora and fauna occurring in a transition zone where two plant communities or successional stages meet and mix (USDA 1988).

Prescribed burning creates contrasting blackened areas and releases smoke into the air that temporarily impairs visibility. Burning does lessen the amount of logging debris that is seen and darkens the color of stumps and snags that, if not burned, would become more noticeable as they bleached over time. In the long term, prescribed burning might allow the regrowth of more aesthetically desirable vegetation.

Chemical Methods

Herbicide sprays have been a preferred treatment for poison oak and other toxic plants. In the past, herbicides have been applied in "spot" applications rather than broadcast spraying (USDA 1988). The use of herbicides may affect the availability of recreational opportunities because of site closures, wildlife habitat changes, loss of edible fruits, and a temporary loss of berry picking opportunities in the treated site (USDA 1988). Designated BLM recreation sites that are treated with herbicides will have signs posted stating the chemical used, date of application, and a contact number for more information. Signs will remain in place for at least 2 weeks after spraying.

Herbicide use reduces the variety of vegetation and may prevent the manifestation of seasonal changes such as spring flowers and fall color in a treated area. Areas treated with herbicides turn brown and contrast with surrounding vegetation for a short period of time. However, applying herbicides could have the positive visual impact of allowing regrowth of more aesthetically desirable vegetation, such as clovers or wildflowers.

LIVESTOCK

The goals of rangeland treatment methods for livestock include suppressing plant species that are toxic and improving forage production by controlling competing vegetation. Livestock could be affected directly by ingesting poisonous weeds and indirectly by changes in forage supply and herbicide exposure.

Manual Methods

Manual treatment methods are labor and cost intensive and therefore may not be effective in controlling competing vegetation on a large scale. However, these methods are species-specific and could be effective in controlling small, localized areas of weeds.

Mechanical Methods

Mechanical treatment methods, such as bulldozing or chaining, may temporarily reduce livestock forage. Sprouting brush or undesirable herbaceous plants may not be controlled effectively with these methods. However, palatability of certain sprouting brush species may be improved.

Biological Methods

When sheep and goats are used for biological control, their performance may decline because they are confined to particular areas that may contain less palatable forage. An effective mix of sheep, goats, and cattle may increase forage overall because each animal has different dietary preferences. Biological treatments using insects and microbes have little potential for affecting livestock because these treat-

ments are slow acting and highly specific for the target species. However, in some situations it is possible that these agents may prohibit animals from using a pasture during relatively short periods.

Prescribed Burning

The burning of rangeland may temporarily reduce grass and forb production, thus reducing available forage for livestock. However, in most cases, policy requires that livestock not be allowed on a burned area for two growing seasons after a prescribed fire so that forage has an opportunity to recover. The burning of rangeland generally results in greater perennial grass production and grazing capacity, as well as increased forage availability from the removal of physical obstructions to plants posed by dense stands of sagebrush or other brush species. Using prescribed burning in concert with herbicide treatments would effect the greatest positive response in situations involving brush land.

Chemical Methods

Chemical treatments are generally applied in a form or at such low rates that they do not affect livestock. Most significant treatments would be applied when livestock are not in the treated pasture, but spot treatments could be applied any time, regardless of the presence of livestock. Animals consuming forage treated with certain herbicides (picloram, 2,4-D, and dicamba) cannot be slaughtered for food within the time specified on the herbicide label. Dairy animals should not be allowed to graze on areas treated with certain herbicides (picloram, 2,4-D, and dicamba) for the time specified on the label. The potential for livestock exposure to herbicides can be reduced by not allowing grazing within the sprayed areas for one grazing season.

Based on the risk analysis in Appendix E-8, the estimated doses for livestock would be well below the EPA risk criterion of 1/5 LD_{50} for all of the program herbicides. Therefore, the risk of direct toxic effects to these animals is negligible, even assuming exposure immediately after herbicide treatment.

Using herbicides is the most efficient and effective way to control some competing vegetation and noxious weeds. However, some aerially applied herbicides also may eliminate some shrubs and trees that livestock need for shelter.

WILD HORSES AND BURROS

Approximately 36,000 wild horses and 3,300 burros roam the sagebrush and desert shrub regions of the program area. Because most of these animals are on public lands in Arizona, Colorado, New Mexico, Nevada, Montana, Oregon, Utah, and Wyoming, BLM must consider the effects on wild horses and burros when proposing land management strategies. As a result of BLM's herd management efforts, herd populations have increased at an annual rate, which is currently 16 percent overall, since 1971 (BLM 1985). Unfortunately, the increased numbers of wild horses and burros, in combination with other resource demand (for example, livestock grazing and outdoor recreation), are exerting greater ecological pressure on their habitats, threatening the balance of these fragile lands (BLM 1985). Therefore, the effects, both positive and negative, on these wild animals as a result of vegetation treatment methods will essentially be the result of habitat alteration in the sagebrush and desert shrub regions.

Manual Methods

Impacts of manual treatment methods on wild horses and burros would, in most cases, be the same as for livestock. Vegetation conversions using manual treatment methods in the habitat areas of wild horses and burros result in an increased diversity and production of grasses, forbs, and shrubs, which should be beneficial for herd populations.

Mechanical Methods

Mechanical vegetation treatment methods may temporarily reduce forage available to wild horses and burros. However, long-term effects would prove beneficial. Mechanical treatments may temporarily displace wild horse herds.

Biological Methods

Biological treatment methods should not significantly affect herd populations in either sagebrush or desert shrub analysis regions. Grazing, as a biological control method, may compete in a minor way with wild horses and burros, but this would be short term and highly localized. Biological treatments using insects and pathogens have little potential for affecting wild horses and burros because these treatments are host-specific and slow-acting.

Prescribed Burning

Prescribed burning would temporarily reduce available forage for wild horses and burros, but ultimately it could result in increased plant production in treated areas. Using prescribed burning with chemical control could effectively control the tar-

geted plant species and allow palatable forage grasses to regenerate rapidly.

Chemical Methods

Wild horses and burros could be indirectly affected by changes in forage supply and herbicide exposure. Restricting grazing in sprayed areas for one grazing season could reduce the potential for this effect. Based on the risk analysis in Appendix E-8, using the representative species of beef cow and pronghorn respectively, the estimated doses for wild horses and burros would be well below the EPA risk criterion of 1/5 LD_{50} for all of the program herbicides. Therefore, the risk of direct toxic effects to these animals is negligible, even assuming exposure immediately after herbicide treatment.

SPECIAL STATUS PLANT AND ANIMAL SPECIES

Unidentified, unknown populations of special status plant and animal species in or near a treated site would be susceptible to any impacts discussed under Impacts to Vegetation and Impacts to Fish and Wildlife. Special status plants and animals may also benefit from vegetation treatments designed to enhance habitat; for example, prescribed burning or the removal of competing exotics.

As discussed in Chapter 2, all BLM actions will be evaluated for potential effects on State and federally listed threatened or endangered species. If the evaluation indicates a "no effect" situation, the action may proceed. If the evaluation indicates a "may affect" situation (may affect includes both beneficial and adverse impacts) on a federally listed species and the adverse impacts cannot be eliminated, Section 7 consultation with the U.S. Fish and Wildlife Service must be conducted. BLM does not have the authority to make a "no affect" finding if a "may affect" situation exists. For federally proposed species, a Section 7 conference will be conducted. There are no legal requirements for Federal candidate species other than BLM policy for multiple-use management and to eliminate the need for listing. BLM will consult with appropriate State agencies for adverse impacts to State-listed species.

WILDERNESS AND SPECIAL AREAS

All vegetation treatments in Wilderness Study Areas (WSAs) and designated wilderness areas would be conducted to avoid impairing the wilderness characteristics of the area. Actions in WSAs are guided by the Interim Management Policy (IMP) until Congress makes a final wilderness decision. The IMP Handbook on page 47 states, "In 'grandfathered' grazing operations, if vegetative manipulation had been done on the allotment before October 21, 1976, and its impacts were noticeable to the average visitor on that date, the improvement may be maintained by applying the same treatment again on the land previously treated." Because most treated areas would have been deleted from the WSAs because of impacts on naturalness, few of these types of situations should occur.

Vegetation treatments in designated wilderness must follow the guidance contained in BLM's Wilderness Management Manual (BLM 1983). The guidance states:

Plant control must be approved only for:

(a) Native plants when needed to maintain livestock grazing operations where practiced prior to the designation of wilderness.

(b) Noxious farm weeds by grubbing or with chemicals when they threaten lands outside wilderness or are spreading within the wilderness, provided the control can be affected [sic] without serious impacts on wilderness values.

Manual Methods

Manual treatments would be the least obtrusive method for use in wilderness areas; they are also the most expensive and least practical. Manual treatments can be very selective and would minimize damage to nontarget vegetation. This treatment would be best suited for small areas invaded by noxious weeds.

Mechanical Methods

Mechanical treatment of vegetation would, in most cases, be incompatible with wilderness (or WSA) management. In very limited, site-specific cases, mechanical means may be appropriate if no other method is feasible. Also, areas mechanically treated in the past may need to be treated again, although most areas affected by mechanical treatment have been deleted from the wilderness process. Mechanical treatments also could be detrimental to other special areas, affecting their scenic value, at least in the short term. Positive effects in the longer term could include greater vegetation diversity, increased wildlife habitat, and better research and education opportunities.

Biological Methods

Biological methods of vegetation treatment that may be considered for BLM use include grazing animals, insects, and pathogens. Because of their special status, wilderness and special areas have strict guidelines for vegetative treatment. Biological control by grazing animals in WSAs would only be practiced as specified in the Interim Management Policy. Vegetation management in designated wilderness areas must follow guidance contained in BLM's Wilderness Management Manual (1983). Insects and pathogens are good candidates for serving as biological agents for noxious weed control in wilderness areas, because they are host-specific and help restore the natural vegetative diversity of the treated area.

Prescribed Burning

Prescribed burning is the most "natural" of the proposed vegetation treatment methods; however, the BLM manual states that prescribed burning may not be used solely as vegetation treatment in wilderness areas. Prescribed burning may be used to maintain fire-dependent natural ecosystems and to reduce the risk of wildfires. Prescribed burning could be beneficial in some areas, such as ponderosa pine forests or chaparral shrublands, where fire exclusion has affected the ecosystem's natural balance.

Chemical Methods

Chemical methods may be used to remove noxious weeds, as long as they are used without adversely affecting wilderness values. Determining whether to conduct aerial spraying on wilderness and WSAs would have to be done on a site-specific basis. Chemical treatment on other special status lands may be used to eliminate the adverse visual effects of other treatment methods, such as chaining and blading.

HUMAN HEALTH AND SAFETY

Manual methods of vegetation treatment should not affect members of the public because they would not handle any of the equipment involved. Workers may receive minor injuries from using hand tools. Workers using power tools also face some risk of major injury. Although mechanical methods should not affect the public, they would be at slight risk of injury from flying debris if they were near a mowing operation on a highway right-of-way project. Workers would be at risk from the same types of injuries that agricultural or construction workers face when they use tractors and other heavy equipment. Neither workers nor members of the public should be affected by any biological vegetation treatment methods.

Sensitive members of the public and some workers may experience minor ill effects, including eye and lung irritation from the smoke of prescribed fires. Workers may suffer burns from igniting or managing prescribed fires, although normal safety precautions should minimize this possibility. Escaped fires may place workers or members of the public at risk, but, again, safety precautions should minimize the possibility of escapes and should limit any risk to human health if wildfires occur.

Herbicide use results in few risks to members of the public, although they may be affected under worst case conditions or if they are exposed as a result of an accidental spraying or spill. There are risks to workers from herbicides, particularly in applications to oil and gas sites or rights-of-way, because of the high application rates used.

Manual Methods

The public is not at risk from manual methods of vegetation treatment; only workers are likely to be affected. Manual methods use hand labor to remove competing vegetation, unwanted plants, and noxious weeds or to create conditions favorable for a desirable plant's growth. Techniques include cutting brush and vegetation with brush saws or chain saws, pulling weeds by hand, scalping the soil, and mulching the vegetation into the soil cover. Manual methods are one of the most expensive treatments and consequently are used on less than 10 percent of the total annual acreage treated.

Although most treatments would be conducted with hand-held implements, approximately 3 percent of the manual activities would involve hand pulling. Hand pulling exposes workers to the hazards of physical contact with irritant weeds, such as leafy splurge (Euphorbia esula), common tansy (Tanacetum vulgare), and poison ivy (Rhus radicans), that cause blisters, inflammation, and dermatitis. Sensitive individuals may react to the pollen of ragweed (Ambrosia sp.), and the close contact of hand pulling could cause significant discomfort.

Some manual treatment programs take place in remote wildlife habitat areas. Workers who happen to surprise or frighten animals are at risk from animal bites or attacks. Workers also risk exposure to biting and sucking insects, such as ticks and mosquitos. Certain tick species carry various diseases, including Rocky Mountain spotted fever and Lyme Dis-

ease. The high potential for encountering poisonous snakes during manual treatments presents another human health risk. Moreover, many treatment areas are remote, and the time necessary to obtain medical attention might complicate some cases of snakebite poisoning.

Workers using manual treatments need physical stamina and muscular strength. When temperatures are high, workers may experience increased fatigue, heat exhaustion, or heat stroke. Falls or other accidents may occur. Continual work in rugged terrain may cause or exacerbate existing chronic health problems, such as ligament damage or arthritis. In extreme cases, exertion from manual methods in rugged terrain may bring on a heart attack or stroke in susceptible workers.

Other potential hazards related to manual operations include injuries from handtools, such as axes, brushhooks, machetes, and mattocks, and hand-held power tools, such as chain saws and brush saws. Workers may cut themselves with tools, be hit by falling brush, or fall onto the sharp ends of cut stumps or brush. Injuries could range from minor cuts, sprains, bruises, or abrasions to severe injuries, such as major arterial bleeding or compound bone fractures. Unusually severe injuries, especially in remote regions, may be fatal. Although the total acreage treated with manual methods under Alternatives 1, 2, 3, and 4 varies by less than 5 percent, risks would increase as the total area treated by these methods is enlarged.

Mechanical Methods

Mechanical vegetation treatment methods should not affect the public. Members of the public would be at slight risk of injury from flying debris if they were near a mowing operation on a highway right-of-way project. Workers would be at risk from the same types of injuries that agricultural or construction workers face when they use tractors and other heavy equipment. High noise levels associated with heavy equipment operations may cause operators to experience partial hearing impairment. Providing hearing protection for workers and notifying the public of field operations should be sufficient to avoid hearing loss. Machinery operators (tractor operators) could be injured by losing control of equipment on steep terrain or by coming into contact with falling trees, flying debris and rocks, and brush. Operators may be severely injured by overturning tractors. Proper treatment design and planning can minimize these risks.

Biological Methods

Biological vegetation treatment methods include the selected grazing of cattle, goats, and sheep and selected introduction of parasitic insects for controlling noxious weeds. Selective livestock grazing is the most common biological treatment, accounting for 94 percent of the acreage treated using this method. Effective biological treatment requires the correct combinations of grazing animals, growth season, system of grazing, and stocking rates to achieve a grazing-induced reduction of less desirable or competing vegetation.

The biological treatment program acreage remains constant under Alternatives 1, 2, 3, and 4. Under Alternative 5, there is a slight decrease in the total acreage to be treated by this method. The combination of livestock numbers and duration of grazing may result in relatively high volumes of fecal matter deposited on biological treatment sites. This factor and the tendency for animals to congregate near live water sources create a potential for fecal contamination of surface waters. Members of the public who drink water downstream of these biologically treated sites may be exposed to fecally contaminated water. However, these risks are minimized by using stock tanks (alternate water sources), constructing range fences, and moving and dispersing grazing stock within treatment areas.

Insects are used for vegetation treatment on approximately 6 percent of the land identified for biological treatment. Pathogens are used for vegetation treatment on less than 0.5 percent of the acreage in the biological program. Both of these treatments involve using parasitic organisms to suppress populations of a specific targeted species of unwanted plants, competing plants, or noxious weeds. Insect and pathogen programs are carefully studied to ensure that they will not harm other nontarget or desirable vegetation species.

These biological methods are unlikely to cause human health effects. Evidence is insufficient to conclude that there is a potential for fecally derived, waterborne disease as a result of livestock grazing. The insects and pathogens proposed for use are target-specific. As more insects and pathogens become available as biological control agents, more will be released on BLM-administered lands.

Prescribed Burning

This section presents a summary of the risks to members of the public and workers from the use of prescribed burning as a vegetation treatment method. A detailed analysis is found in Appendix D.

Risks From Fire

If a burn escapes and causes a wildfire, members of the public in adjacent areas may be endangered.

Prescribed burning presents various hazards to ground crews, who could possibly receive injuries ranging from minor burns to severe burns that may result in permanent tissue damage. However, standard safety procedures, protective gear, and training are integrated into every prescribed fire plan and are expected to reduce or eliminate most hazards. If a burn escapes and causes a wildfire, the potential is higher for severe worker injuries, including fatalities.

Risks From Smoke

A quantitative assessment was made of the risks to members of the public and workers from exposure to the combustion products of vegetation that may result from a prescribed burn. The hazard presented by the various combustion products was evaluated, exposures were estimated, and risks were assessed.

Hazard Evaluation

Substances that may be found in wood smoke include particulate matter, carbon dioxide, nitrogen oxides, aldehydes, and ketones. The proportion of each varies widely, depending on factors such as moisture content in the vegetation and the temperature of the fire.

Particulate matter is a result of incomplete fuel combustion. Fine particulate matter, with a particle diameter of less than 2.5 microns, has a greater ability than do larger particles to avoid the body's defense mechanisms and reach the lungs. Carbon dioxide, nitrogen oxides, and other gaseous components of smoke generally decompose or diffuse into the atmosphere relatively quickly. However, some may attach to particulate matter and remain more concentrated and protected from decomposition. For example, aldehydes, which inhibit the removal of foreign material from the respiratory tract, may be absorbed onto the surface of particles. Polynuclear aromatic hydrocarbons, or PAHs, are of significant toxicological concern in evaluating health effects from wood smoke. The PAHs in wood smoke include at least five carcinogenic chemicals—benzo(a)pyrene, benzo(c)phenanthrene, perylene, benzo(g,h-,i)perylene, and the benzofluoranthenes.

Exposure Estimation

Exposures to the carcinogenic and possibly carcinogenic PAHs in wood smoke from burning vegetation were estimated using methods developed by Dost (1986). Various atmospheric exposure levels were estimated that might be experienced by members of the public and workers, providing a range of doses from typical to worst case. A detailed explanation of the methodology is presented in Appendix D.

Risk Analysis

Risks were calculated by multiplying the atmospheric concentrations of the combustion products by the total exposure time and the cancer potency of each chemical. Based on these calculations, estimated cancer risks are not expected to exceed the criteria of 1 in 1 million for any member of the public or worker, even in extreme cases, as a result of the carcinogenic PAHs in the smoke from burning vegetation. The cancer risk probabilities are presented in Appendix D.

Smoke from prescribed fires will impact air quality. Sensitive members of the public may experience eye, throat, or lung irritation from these exposures. Possible effects on workers as a result of smoke exposure may include eye irritation, coughing, and shortness of breath.

Risks From Herbicides Used in a Brown-and-Burn Operation

Vegetation may be treated with herbicides several weeks before beginning a prescribed burn, with the goal of drying the vegetation to accomplish a more efficient burn. The herbicides that may be used in this method of treatment are 2,4-D, glyphosate, hexazinone, picloram, and triclopyr.

In this assessment of risk from volatilization of herbicide residues, the atmospheric levels of the herbicides were compared to threshold limit values (TLVs), which indicate an acceptable daily exposure level for workers to airborne chemicals over the course of their careers. Appendix D includes detailed information on the estimation of the atmospheric herbicide levels that may result from a brown-and-burn operation and a comparison of those levels to TLVs.

All estimated exposure levels are significantly less than the levels determined to be safe exposure levels. The risks were calculated using a smoke density that is likely to occur onsite and therefore represent risks to workers. Members of the public would be exposed to much lower atmospheric concentrations than these and would have a margin of safety that is even greater than that calculated for workers. Based on this method of risk estimation, neither workers nor the public are expected to be at risk from the herbicide residues volatilized in a brown-and-burn operation.

Impacts by Program Areas

Prescribed fire will only be used as a vegetation treatment method on rangeland and public domain forests in the BLM program. Therefore, there will be no effects on human health from the use of this method on oil and gas sites, rights-of-way, or recreational and cultural sites.

Effects on human health from the use of prescribed fire on rangeland and in forests vary by the type of land, based on the amount of fuel available for burning and its moisture content. Drier fuel produces more smoke. A grassland with several thousand pounds per acre of fine fuels, all of which will essentially be consumed, may produce far more smoke than a forest underburn, where there is just enough litter to carry the fire. The risk of short-term health effects from smoke in a grass fire could be high to those in the immediate vicinity, because essentially all of the fuel is consumed in the flaming front of the fire; however, safety equipment and standard operating procedures mandated by BLM minimize the potential for these effects.

Chemical Methods

Potential human health effects from using the 19 proposed herbicides—amitrole, atrazine, bromacil, chlorsulfuron, clopyralid, 2,4-D, dalapon, dicamba, diuron, glyphosate, hexazinone, imazapyr, mefluidide, metsulfuron methyl, picloram, simazine, sulfometuron methyl, tebuthiuron, and triclopyr (Table 1-2)—the inert ingredient kerosene, and the herbicide carrier diesel oil were evaluated in a risk assessment (Appendix E). In essence, the risk assessment quantified general systemic and reproductive human health risks for a given herbicide by dividing the dose found to produce no ill effects in laboratory animal studies by the exposure a person might get from applying the herbicide or from being near an application site. Human cancer risk was calculated for those herbicides that caused tumor growth in laboratory animal studies by multiplying a person's estimated lifetime dose of the herbicide by a cancer probability value (cancer potency) calculated from the animal tumor data. The risk assessment included a qualitative analysis of the risk of heritable mutations and synergistic effects.

Risk Assessment Structure

The risk assessment consisted of three steps—a hazard analysis, an exposure analysis, and a risk analysis.

The hazard presented by a chemical pesticide is its characteristic toxicity or poisonous quality that may cause human health effects. Those effects may be brief and reversible, such as nasal irritation or nausea in humans who receive small amounts, or much more severe, such as permanent organ damage or, in the extreme, death from larger amounts. All chemicals are injurious to health at some level of intake, even commonly consumed items such as aspirin, table salt, and sugar. The more toxic chemicals produce severe effects in much lower amounts than the less toxic chemicals.

Exposure is the amount of pesticide in a person's immediate surroundings (in the air, on the skin, in the food eaten, or in drinking water). The amount that enters the body—that one ingests, inhales, or has penetrated the skin during a specified time period—is the dose. A single dose is usually expressed in milligrams of chemical per kilogram of a person's body weight (mg/kg). Doses that occur over time are expressed per unit of time as milligrams per kilogram per day (mg/kg/day).

Risk from a chemical pesticide is the probability or expectation that if a person is exposed to the chemical under a specified set of circumstances (for example, if one eats berries growing near a site that has just been sprayed), that person may receive a dose that causes him or her to experience the kinds of toxic effects seen in laboratory toxicity studies on that chemical. Human health risk in the BLM vegetation treatment program is the possibility that humans will experience toxic effects from exposure to one of the proposed herbicides.

Hazard Analysis

Evaluations of potential human health effects caused by pesticide exposure are generally based on results of toxicity tests in laboratory animals. The hazard analysis section (Appendix E, Section E3) describes the human health effects associated with each of the BLM herbicides. These laboratory animal data were supplemented by data on actual human exposure when available.

The routes of administration of test material for laboratory animal toxicity testing are selected based on the most probable route of human exposure. These routes of exposure include oral (by consumption of feed mixed with test material), dermal (application of the test material to the skin), and inhalation (exposure through breathing vapors or aerosol fumes). Levels of exposure (or doses) are expressed as milligrams of the chemical per kilogram of body weight of the test animal.

The reference dose (or acceptable daily intake) is an estimate (with uncertainty spanning perhaps an order of magnitude) of daily exposure of the human population (including sensitive subgroups) that is not likely to have an appreciable risk of harmful effects during a lifetime (EPA 1988). The reference

dose, established by EPA, is selected using the lowest no-observed-effect level (NOEL) from the most relevant test species. An uncertainty factor of 100 is usually applied (10 to account for variation within the test animal species and 10 for extrapolation from animals to humans). The reference dose value is relevant in this discussion to the toxicity of the vegetation treatment herbicides because it provides a useful point of reference by which to gauge potential exposures of workers and the public used in this analysis.

Toxicological tests that were reviewed are in six categories.

Acute Toxicity

Acute toxicity studies are conducted to determine the LD_{50} (the median lethal dose)—the single dose that kills 50 percent of the test animals. Acute toxicity tests also are used to estimate dosage levels for longer term studies. Acute toxicity studies are usually conducted over a 1- to 14-day period, depending on the purpose of the study.

Subchronic Toxicity

Subchronic studies establish the dose level at which no effects are observed in the test animals. This level is termed the NOEL. This type of toxicity study generally lasts 3 weeks to 3 months.

Chronic Toxicity

Chronic toxicity studies are longer (1 to 2 years) studies conducted to establish a NOEL. Chronic studies are useful in determining the long-term effects of a chemical, particularly its carcinogenic effects.

Reproductive/Developmental Toxicity

Reproductive studies are conducted to determine whether a chemical may diminish reproductive success, shown by effects on the fertility (production of germ cells), fetotoxicity (direct toxicity on the developing fetus), maternal toxicity, and survival and weight of offspring. Developmental studies (also called teratology studies) determine the potential of a chemical to cause malformation in an embryo or developing fetus between the time of conception and birth.

Oncogenicity/Carcinogenicity Studies

Oncogenicity studies examine the potential for a chemical to cause malignant (cancerous) or benign (noncancerous) tumors when consumed over the test animal's lifetime. Data on tumor formation are used to determine a cancer potency value. This value is defined as the increase in likelihood of getting cancer from a unit increase (1 mg/kg/day) in the dose of a chemical and is expressed as the probability per mg/kg/day.

Mutagenicity Assays

Mutagenicity assays are used to determine the ability of a chemical to cause physical changes (mutations) in an organism's basic genetic material.

Figure 3-3 summarizes the acute oral LD_{50} values in rats for each chemical. Figure 3-4 summarizes NOELs for general systemic effects, such as decreases in body weight and food consumption, gross or microscopic abnormalities in tissues, or changes in hematology and blood chemistry. Figure 3-5 presents NOELs for reproductive or developmental effects. Sources for the data in Figures 3-3, 3-4, and 3-5 are found in Section E3 of Appendix E.

Exposure Analysis

The human health risk assessment analyzed potential health effects to anyone who might be exposed to the proposed herbicides or carriers as a result of BLM rangeland, forest land, oil and gas site, right-of-way, or recreational and cultural site vegetation treatments. The risk assessment estimated human exposures for the herbicides proposed to be used for each category of treatment at the application rates listed in Table 1-2. The detailed methodology (Appendix E, Section E4) used to estimate human exposures to the proposed BLM herbicides is outlined here.

Two groups of people were considered at risk from each type of treatment—the public (who could be exposed if herbicide spray drift got on their skin, if they brushed up against sprayed vegetation, if they ate food items such as berries growing in or near sprayed areas or fish containing herbicide residues, or if they consumed water containing residues) and workers (including aerial, ground vehicle, backpack, and ground hand applicators). Exposure scenarios to estimate worker and public exposures were created for each of the five categories of treatment: rangeland, forests, rights-of-way, oil and gas sites, and recreation areas.

To represent the range of possible exposures from the BLM vegetation treatment program, three levels of exposure were estimated—routine-realistic, routine-worst case, and accidental.

Routine-realistic exposure scenarios used assumptions about typical herbicide applications, including herbicides used and application rates (Table 1-2), average site size, and normal distance to exposure points to estimate worker and public doses that might occur as a result of routine herbicide applications.

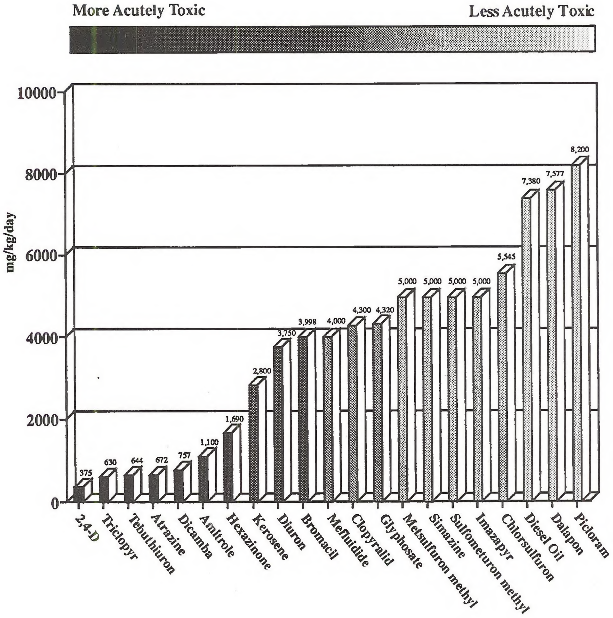


Figure 3-3
Oral LD $_{50}$s in Rats
mg/kg/day

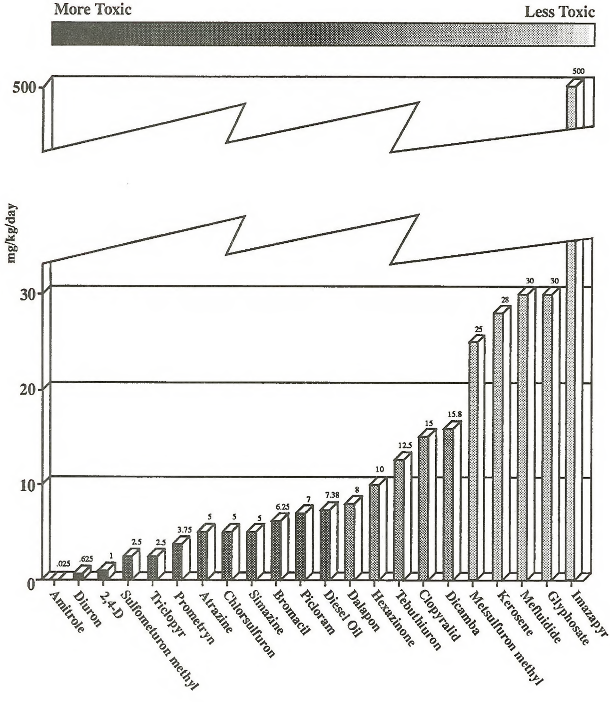


Figure 3-4
Systemic NOELS
mg/kg/day

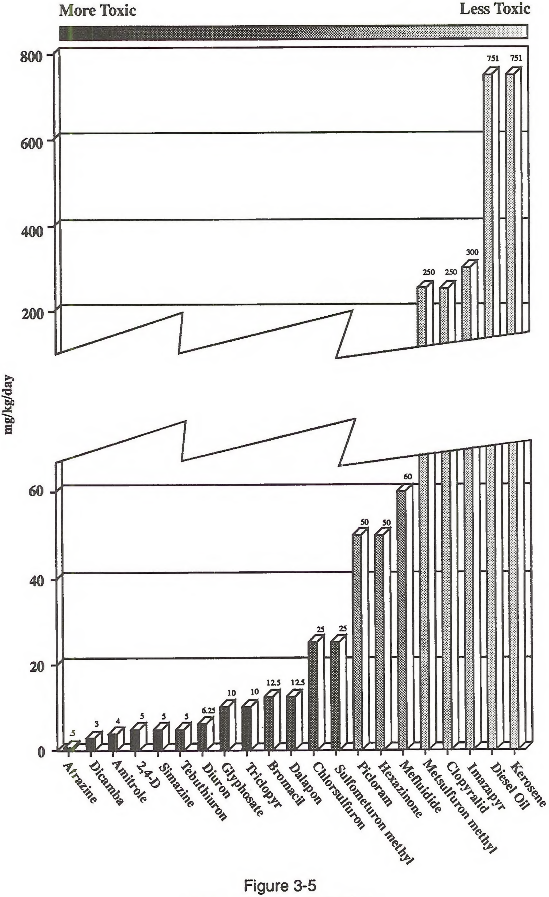


Figure 3-5
Reproductive NOELS
mg/kg/day

Routine-worst case scenarios were based on extreme values of the routine-realistic application characteristics, including largest site size and closest distance to exposure points to estimate the higher doses that might occur in less than 5 percent of all treatments. Routine-worst case assumptions were incorporated in the analysis to obtain the maximum exposures that may occur, except in the case of an accident.

Because the potential for error exists in all human activity, accidental exposure levels were estimated for a number of events that, in fact, may occur only rarely or never in the course of implementing BLM's proposed vegetation treatment program.

Exposure Estimates for the Public

Members of the public could be exposed to the herbicides through dermal, inhalation, and dietary routes. Mathematical modeling (detailed in Appendix E, Section E4), based on field studies of herbicide residues, was used to estimate residue deposition on skin, in water, and on vegetation resulting from spray drift. Dermal and inhalation exposures to the public were estimated using routine-realistic and routine-worst case assumptions about the distance they are exposed downwind of a treated site. Dietary exposure to the public was estimated using three possible diet items, which included eating 0.4 kg (0.9 lb) of berries with drift residue, drinking 2 liters (about 2 quarts) of pond water that has received drift, and eating 0.4 kg (0.9 lb) of fish from a pond that has received spray drift.

In addition to estimating public exposures from each exposure route, multiple exposures were estimated assuming an individual could be exposed in several ways as a result of a single-spray operation. These multiple exposures, representing the worst case for cumulative public exposure from one application, included the following:

- Hiker—having dermal exposure from spray drift; contacting vegetation receiving spray drift, specific for a hiker; or drinking 2 liters (slightly more than 2 quarts) of water from a pond receiving spray drift.
- Berrypicker—touching vegetation with drift residues, specific for a berrypicker; drinking 2 liters (slightly more than 2 quarts) of water from a pond receiving spray drift; or eating 0.4 kg (about 14 ounces) of berries that have received spray drift.
- Angler—having dermal exposure from spray drift; touching vegetation with drift residues, specific for a hiker; drinking 2 liters (slightly more than 2 quarts) of water from a pond receiving spray drift; or eating 0.4 kg (about 14 ounces) of fish that were taken from a pond receiving spray drift.
- Nearby resident—having dermal exposure from spray drift; or contacting vegetation receiving spray drift, specific for a hiker.

Lifetime Exposure Estimates for Public Cancer Risk

The cancer risk analysis for the public was based on four exposures per year for 5 years over a 70-year lifetime. Nineteen of the exposures were assumed to be at the routine-realistic level; one was assumed to be at the worst case level. This is in line with the estimated 5-percent probability of a person receiving a worst case exposure.

Worker Exposure Estimates

Workers may be exposed dermally or by inhalation during routine operations, such as mixing and loading herbicides into application equipment or applying herbicides to sites. Actual field worker exposure monitoring studies were used to estimate doses to workers.

Four different types of workers (aerial applicators, backpack applicators, ground vehicle applicators, and ground hand applicators) were used to estimate doses to workers in the routine-realistic and routine-worst case scenarios. For all worker scenarios, routine-realistic exposures were calculated assuming average adjusted exposure rates based on field study data (detailed in Appendix E, Section E4) and application rates and frequencies estimated for the BLM vegetation treatment program.

Lifetime Exposure Estimates for Worker Cancer Risk

Carcinogenic risk for workers was calculated based on 10 years of employment with 6, 9, 10, and 14 exposures per year for aerial, ground vehicle, backpack, and ground hand applicators respectively. Workers are assumed to receive 9 years of realistic exposures and 1 year of worst case exposures.

Exposure Estimates From Accidents

Accidental doses to the people were estimated using the following scenarios:

- Consumption of 2 liters (slightly more than 2 quarts) of water from a reservoir that has received an accidental jettison of 80 gallons from an aircraft.
- Consumption of 2 liters (slightly more than 2 quarts) of water that has received a spill of 2,000 gallons of herbicide mix from a batch truck.
- Consumption of 0.4 kg (about 14 ounces) berries that have been directly sprayed.

- Dermal and inhalation exposure from a direct spray.
- Consumption of 2 liters (slightly more than 2 quarts) of water that has been directly sprayed.
- Consumption of 0.4 kg (about 14 ounces) of fish from a pond that has been directly sprayed.
- Immediate reentry—dermal exposure of a hiker or a berrypicker from contacting vegetation at a site that has just been sprayed.

Uncertainty in the Risk Analysis

There is uncertainty in relating dose levels used in laboratory animal studies to doses that may cause health effects in humans. To allow for the uncertainty in extrapolating from NOELs in laboratory animals to safe levels for humans, uncertainty factors of 10 were used to account for interspecies differences (animals to humans) and 10 to account for intraspecies differences (variations of sensitivity within the human population). This 10 times 10 or 100-fold safety factor was used in this analysis to evaluate acceptable risk levels. The margin of safety (MOS) between the estimated exposure and the NOEL is based on a comparison with the dose level that produced no effects in laboratory animals. Because most laboratory animal NOELs were established from daily exposures of up to 2 years, this comparison tends to overestimate risks to humans.

Human Health Risk Analysis

The risk from a chemical pesticide is the probability or expectation that if a person is exposed to the chemical under a specified set of circumstances (for example, if he or she eats berries growing near a site that has just been sprayed), he or she may receive a dose that causes him or her to experience the kinds of toxic effects seen in laboratory toxicity studies on that chemical. Human health risk in the BLM vegetation treatment program is the possibility that humans will experience toxic effects from exposure to one of the proposed herbicides.

This section describes the potential human health effects of using the 19 proposed BLM herbicides and carriers in BLM's vegetation treatment program. This risk analysis quantifies general systemic and reproductive human health risks for a given herbicide by dividing the dose found to produce no ill effects in laboratory animal studies by the exposure a person might get from applying the herbicide or from being near an application site. Human cancer risk has been calculated for those herbicides that have caused tumor growth in laboratory animal studies by multiplying a person's estimated lifetime dose of the herbicide by a cancer probability value (cancer potency) calculated from the animal tumor data. The risk analysis includes a qualitative analysis of the risk of heritable mutations, synergistic effects, and cumulative effects.

The risk analysis compared the scenario-based estimates of doses to workers and the public with the toxicity levels detailed in the hazard analysis. These comparisons were used to determine the risk to humans under the specified circumstances of exposure.

For threshold effects, the doses were compared to NOELs determined in the most sensitive animal test species. An MOS, which is the animal NOEL divided by the estimated human dose, was computed to relate the doses and effects seen in animals to estimated doses and possible effects in humans. For example, an animal NOEL of 20 mg/kg divided by an estimated human dose of 0.2 mg/kg gives an MOS of 100, which is comparable to the 100-fold safety factor described in the Hazard Analysis section as being generally recognized as safe for humans. The larger the margin of safety (the smaller the estimated human dose compared to the animal NOEL), the lower the risk to human health. Where MOSs are greater than 100, the risk can be considered low to negligible for the chemical in question. MOSs less than 100 indicate a risk of toxic effects and should be the focus of mitigation.

When an estimated dose exceeded a NOEL, the dose was divided by the NOEL and the MOS preceded with a negative sign. The result was not an MOS, but simply a negative ratio. A negative ratio does not necessarily lead to the conclusion that there will be human toxic effects because NOELs used in this risk analysis are levels at which no adverse effects were observed in long-term animal studies. Negative MOSs, however, identify the most important exposures to mitigate. Estimated doses are not likely to occur often or on a long-term basis. This applies particularly to doses that are not likely to occur more than once, such as those to the public.

Systemic effects were evaluated based on the lowest systemic NOEL found in a chronic or subchronic feeding study of dogs, rats, or mice. Reproductive effects were evaluated based on the lowest maternal toxic, fetotoxic, or teratogenic NOEL found in a two- or three-generation reproductive study or in a teratology study.

An analysis of cancer risk was conducted for the pesticides suspected to be possible human carcinogens by multiplying estimates of lifetime dose by cancer potency estimates derived from laboratory animal study data to obtain a probability that a tumor will occur as a result of the specified exposure. Cancer risk from the herbicides for the public has been calculated for 20 exposures (19 realistic, 1 worst case) in a lifetime. Cancer risk to workers from

the pesticides has been calculated assuming 10 years of employment, with 9 years of realistic and 1 year of worst case exposures.

Mutagenic risks for these herbicides were evaluated on a qualitative rather than a quantitative basis, with a statement of the probable risk based on the available evidence of mutagenicity and carcinogenicity in laboratory studies.

Overview of Risk Assessment

There are no risks to members of the public from the use of hand application methods in any of the programs, even assuming worst case conditions. There are no significant risks to members of the public from the application of any herbicide by any method used by BLM on public recreation and cultural sites, even in the worst case scenario. Routine-realistic applications of amitrole to rangeland, public domain forest land, or rights-of-way by aerial or ground mechanical methods may lead to a significant risk to members of the public of experiencing systemic effects, as well as increasing the risk of cancer beyond the criterion of a 1 in 1 million probability. For routine-realistic rangeland treatments, this risk is only present as a result of eating fish from a body of water that has received amitrole spray drift or for the multiple exposures of an angler. However, the conservative assumptions made during the risk assessment may have overstated exposures and therefore risks, especially considering the remote location of most treatment sites.

Workers applying the herbicides on a regular basis face some risks, even assuming typical working conditions. These risks increase with the number of acres treated in a day and the toxicity of the herbicides used in each program area.

In general, mixer-loaders face higher risks from several herbicides in aerial applications than do pilots or fuel truck operators. However, certain herbicides present risks to each of these aerial application team members in all programs in which aerial spraying is used. With the exception of fuel truck operators, even typical exposures present some degree of risk.

Backpack applicators are not at risk from typical exposures that may be encountered during rangeland or public recreation and cultural site applications, but a risk is present when treating public domain forests, oil and gas sites, or rights-of-way.

Except for workers treating public recreation and cultural sites, the applicators, mixer-loaders, and applicator/mixer-loaders in ground mechanical operations face some degree of risk, even in typical scenarios. Risks for mixer-loaders are generally higher than those of applicators or of applicator/mixer-loaders, who divide their time between the two tasks.

Workers using hand application methods are faced with some risks, even in the realistic case. Use of atrazine, 2,4-D, triclopyr, or tebuthiuron most commonly leads to risks in excess of the criteria employed in this risk assessment.

Accidents present significant risks to any person who may receive the indicated exposures. The probability of any of these events occurring is small, however, because of normal safety precautions during applications, the remoteness of treatment units, the use of protective clothing by workers, and standard operating procedures required by BLM. Combined with this fact, the possibility of adverse health effects, such as those that may be predicted from accidental exposures, is remote.

The following discussions present the results of the risk analysis for the herbicides and carriers proposed for use on BLM-managed lands in the 13 Western States. The estimated exposures on which the risk estimates are based were calculated using the herbicide application information and methods described in Appendix E, Section E4. The MOSs and cancer risk values are based on the methods described briefly in this chapter and in detail in Appendix E, Section E5. The risks that exceed the risk criteria (MOS less than 100 or cancer risk greater than 1 in 1 million) are summarized in Tables 3-7 through 3-21 for each program for members of the public and workers. In the following sections, risks are discussed only for those scenarios in which the risks exceed these criteria.

Risks From Rangeland Herbicide Treatments

Those applications that present a significant risk from herbicide use on rangeland under the BLM program are summarized in Table 3-7 for members of the public and Table 3-8 for workers. The herbicides used on rangeland are amitrole, atrazine, clopyralid, 2,4-D, dalapon, dicamba, glyphosate, hexazinone, imazapyr, picloram, tebuthiuron, and triclopyr, as well as the carriers diesel oil and kerosene.

In terms of herbicide application, other agencies or private individuals in the vicinity of BLM-treated sites may be using other treatments of vegetation with many of the same chemicals as BLM proposes to use. Also, other pesticides may be used in agriculture, forestry, or industrial applications that might create an overall pesticide burden in an area where BLM plans to treat. While the herbicides used in the BLM treatment program are not expected to have an impact on water quality, streams that may receive some herbicide drift or runoff from the BLM areas also may be receiving drift or runoff of these other chemicals, and this cumulative pesticide burden may place the aquatic ecosystems at risk. Because of the remoteness of most BLM program treatment sites, this type of occurrence should be relatively rare.

Table 3-7

High Risks to Members of the Public From Herbicide Use on Rangeland

Exposure Scenario	Typical Exposures Systemic	Typical Exposures Reproductive	Worst-case Exposures Systemic	Worst-case Exposures Reproductive	Worst-case Exposures Cancer
Aerial Applications					
Spray Drift, Dermal	—	—	—	—	—
Vegetation Contact, Hiker	—	—	—	—	—
Vegetation Contact, Picker	—	—	—	—	—
Drinking Water	—	—	AM	—	—
Eating Berries	—	—	—	—	—
Eating Fish	AM	—	AM, 4D	—	—
Hiker	—	—	AM	—	—
Berrypicker	—	—	AM	—	—
Angler	AM	—	AM, 4D	—	AM
Nearby Resident	—	—	—	—	—
Backpack Applications					
Spray Drift, Dermal	—	—	—	—	—
Vegetation Contact, Hiker	—	—	—	—	—
Vegetation Contact, Picker	—	—	—	—	—
Drinking Water	—	—	—	—	—
Eating Berries	—	—	—	—	—
Eating Fish	—	—	—	—	—
Hiker	—	—	—	—	—
Berrypicker	—	—	—	—	—
Angler	—	—	—	—	—
Nearby Resident	—	—	—	—	—
Ground Mechanical Applications					
Spray Drift, Dermal	—	—	—	—	—
Vegetation Contact, Hiker	—	—	—	—	—
Vegetation Contact, Picker	AM	—	AM	—	AM
Drinking Water	—	—	—	—	—
Eating Berries	—	—	—	—	—
Eating Fish	—	—	—	—	—
Hiker	—	—	—	—	—
Berrypicker	AM	—	AM	—	AM
Angler	—	—	—	—	—
Nearby Resident	—	—	—	—	—

AM = Amitrole; 4D = 2,4-D

Amitrole - BLM has reexamined the risk assessment and examined additional data. BLM has determined that amitrole is no longer considered for proposed use in this document. Amitrole will be deleted in the Record of Decision.

Note: High risks are defined as those exposures that may result in a margin of safety less than 100 or a cancer risk greater than 1-in-1 million.

Another cumulative impact would be to workers who apply herbicides, both aerially and by ground methods. Some workers who apply herbicides in the BLM treatment program may apply or otherwise come into contact with the same herbicides or other chemicals used in agricultural, forestry, and industrial programs. This would result in workers being cumulatively exposed to a greater amount of an herbicide on an annual or lifetime basis or a wider variety of pesticides than any other individuals. For chemicals that pose a cancer risk to workers, the risks would depend on total lifetime exposure, which would include both BLM treatments and the other applications. In terms of possible synergistic effects, the wider the variety of chemicals handled, the greater the possibility of synergistic effects.

Risks to Members of the Public. In routine-realistic cases, members of the public may be at risk of systemic effects or have an increased cancer risk from some exposures that may result from the use of amitrole to treat rangeland vegetation.

Aerial Applications. Routine-realistic aerial applications of the BLM herbicides present few risks to members of the public. The MOS is less than 100 for systemic effects from eating fish from a body of water that has received amitrole spray drift and for the cumulative exposure that an angler may receive from amitrole exposure.

Routine-worst case aerial applications present a risk of systemic effects from drinking water that has received amitrole spray drift; from eating fish from a body of water that has been contaminated with drift from nearby amitrole or 2,4-D applications; from cumulative exposure to amitrole by a hiker, berrypicker, or angler; and from cumulative exposure to 2,4-D by an angler.

No routine aerial applications of the herbicides on rangeland present a significant risk of adverse reproductive or teratogenic effects to members of the public. An angler's cumulative exposure to amitrole results in a risk of cancer that slightly exceeds the cancer probability risk criterion of 1 in 1 million.

Backpack Applications. Backpack applications of herbicides on rangeland do not present any significant risks to members of the public. There are no significant risks of reproductive or teratogenic effects to members of the public from backpack applications of the BLM herbicides on rangeland. No cancer risk estimate exceeds 1 in 1 million for a member of the public in this scenario.

Ground Mechanical Applications. Routine-realistic and routine-worst case ground mechanical applications of amitrole present a risk of systemic effects from vegetation contact by a berrypicker and from the cumulative exposure of a berrypicker. No significant adverse reproductive effects were predicted for members of the public from ground mechanical applications on rangeland. Vegetation contact by a berrypicker may result in a significant cancer risk from amitrole, as may the cumulative exposure received by a berrypicker.

Hand Applications. BLM does not use these methods on rangeland.

Risks to Workers. In routine-realistic cases, some workers may be at risk of systemic effects from amitrole, atrazine, 2,4-D, dalapon, dicamba, tebuthiuron, triclopyr, or diesel oil; reproductive effects from atrazine, 2,4-D, dalapon, dicamba, glyphosate, tebuthiuron, or triclopyr; and increased carcinogenic risk from amitrole, atrazine, or 2,4-D.

Aerial Applications. Imazapyr and picloram risk estimates for workers in aerial applications result in MOSs greater than 100 in both the routine-realistic case and routine-worst case for all aerial application worker categories. Imazapyr is not considered carcinogenic in this risk assessment. Although picloram may be a potential carcinogen, cancer risk estimates are less than 1-in-1 million for all workers in aerial rangeland herbicide applications.

Routine-realistic aerial applications of herbicides to BLM-managed rangeland may result in significant risks of systemic effects to pilots from amitrole, 2,4-D, or triclopyr and to mixer-loaders from amitrole, atrazine, 2,4-D, dalapon, dicamba, tebuthiuron, triclopyr, or diesel oil. No high systemic risks for fuel truck operators are expected as a result of routine-realistic aerial applications. In the routine-worst case, there are significant risks to pilots from amitrole, atrazine, 2,4-D, dalapon, dicamba, glyphosate, hexazinone, tebuthiuron, triclopyr, diesel oil, or kerosene; to mixer-loaders from amitrole, atrazine, clopyralid, 2,4-D, dalapon, dicamba, glyphosate, hexazinone, tebuthiuron, triclopyr, diesel oil, or kerosene; or to fuel truck operators from 2,4-D.

In the routine-realistic case, significant reproductive risks are present for pilots from the use of atrazine, 2,4-D, dicamba, or tebuthiuron and for mixer-loaders from atrazine, 2,4-D, dalapon, dicamba, glyphosate, or tebuthiuron. There are no high reproductive risks to fuel truck operators under realistic conditions. In the routine-worst case, there are significant adverse reproductive risks to pilots and mixer-loaders from atrazine, 2,4-D, dalapon, dicamba, glyphosate, tebuthiuron, or triclopyr and to fuel truck operators from atrazine or dicamba.

Cancer risks exceed 1 in 1 million for pilots and mixer-loaders from amitrole, atrazine, or 2,4-D. No estimated cancer risks for fuel truck operators in rangeland aerial herbicide applications exceed 1 in 1 million.

Backpack Applications. Backpack applicators are not expected to face any significant systemic, reproductive, or cancer risks from the use of clopyralid, hexazinone, imazapyr, picloram, tebuthiuron, or kerosene on rangeland.

Routine-realistic backpack applications of herbicides to BLM-managed rangeland are not expected to result in significant systemic risks to applicators. However, in the routine-worst case scenario, there are high systemic risks from amitrole, atrazine, 2,4-D, dalapon, triclopyr, and diesel oil.

There are no significant reproductive risks to backpack applicators applying herbicides to rangeland in the realistic case. In the worst case, there are notable risks from atrazine, 2,4-D, dalapon, dicamba, and glyphosate.

Cancer risk estimates are significant for backpack applicators using atrazine or 2,4-D on rangeland.

Ground Mechanical Applications. No excess systemic, reproductive, or cancer risks to workers from rangeland herbicide application by ground mechanical methods are expected to result from the use of clopyralid, hexazinone, imazapyr, picloram, or kerosene.

For workers using ground mechanical equipment to apply herbicides to rangeland, there are significant systemic risks in the routine-realistic case for applicators and applicator/mixer-loaders from 2,4-D and for mixer-loaders from amitrole, or 2,4-D. In the worst case, there are high risks to applicators and applicator/mixer-loaders from amitrole, atrazine, 2,4-D, dalapon, dicamba, glyphosate, tebuthiuron, triclopyr, or diesel oil and to mixer-loaders from amitrole, atrazine, 2,4-D, dalapon, dicamba, tebuthiuron, triclopyr, or diesel oil.

In the realistic case, there are significant reproductive risks from atrazine to applicators, mixer-loaders, and applicator/mixer-loaders. In the worst case, high reproductive risks are expected for applicators and applicator/mixer-loaders from atrazine, 2,4-D, dalapon, dicamba, glyphosate, tebuthiuron, or triclopyr and for mixer-loaders from atrazine, 2,4-D, dalapon, dicamba, glyphosate, or tebuthiuron.

There are significant cancer risks from ground mechanical rangeland herbicide application for applicators, mixer-loaders, and applicator/mixer-loaders from atrazine and 2,4-D.

Hand Applications. Hand application of herbicides is not used on BLM-managed rangeland.

Risks From Public Domain Forest Land Herbicide Treatments

Scenarios in which the MOSs are less than 100 or cancer risk probabilities are greater than 1 in 1 million are summarized in Table 3-9 for members of the public and Table 3-10 for workers. The herbicides used on public domain forest lands are amitrole, atrazine, chlorsulfuron, 2,4-D, dalapon, dicamba, glyphosate, hexazinone, imazapyr, picloram, simazine, tebuthiuron, and triclopyr, as well as the carriers diesel oil and kerosene

Risks to Members of the Public. In the routine-realistic case, members of the public may be at risk of systemic effects and have an increased carcinogenic risk from the use of amitrole on forests.

Aerial Applications. Routine-realistic aerial application of BLM herbicides to public domain forest land may present a significant risk of adverse systemic effects to members of the public from eating fish from a body of water that has received amitrole spray drift and from the multiple exposures to amitrole that an angler may receive. Worst case aerial applications pose elevated systemic risks to those drinking water contaminated by amitrole spray drift, to those eating fish from a body of water contaminated by spray drift from amitrole or 2,4-D, to hikers with multiple exposures to amitrole, and to berrypickers' or anglers' multiple exposures to amitrole, atrazine, or 2,4-D.

Members of the public are not expected to have any significant reproductive risks from the routine-realistic aerial application of the BLM herbicides to public domain forest land. However, in the routine-worst case, there is a significant risk to berrypickers who may be exposed through several routes to atrazine.

Single routes of exposure are unlikely to result in a significant cancer risk to members of the public from aerial applications. The multiple exposures received by an angler may lead to a significant cancer risk from amitrole.

Backpack Applications. Estimated systemic MOSs for members of the public for routine exposures in this scenario are all greater than 100. There are no significant reproductive risks to members of the public from routine exposures in this scenario. There are no significant cancer risks to members of the public from backpack applications of herbicides on BLM-managed public domain forest land.

Ground Mechanical Applications. In the routine-realistic case, members of the public may have a risk of adverse systemic effects from the use of ground mechanical herbicide application of amitrole. In the routine-worst case, there is a significant risk of systemic effects from vegetation contact by a berrypicker and the multiple exposures that a berrypicker may receive from amitrole, and 2,4-D.

In the routine-realistic case, there are no significant reproductive risks from the ground mechanical herbicide application to members of the public. In the routine-worst case, there is a significant risk of reproductive effects from atrazine from the vegetation contact that a berrypicker may have and the multiple exposures of a berrypicker.

A significant risk of cancer exists from amitrole from the vegetation contact and the multiple exposures that a berrypicker may have.

Table 3-8

High Risks to Workers From Herbicide Use on Rangeland

Exposure Scenario	Typical Exposures		Worst-case Exposures		
	Systemic	Reproductive	Systemic	Reproductive	Cancer
Aerial Applications					
Pilot	AM, 4D, TC	AT, 4D, DC, TB	AM, AT, 4D, DP, DC, GP, HX, TB, TC, DE, KE	AT, 4D, DP, DC, GP, TB, TC	AM, AT, 4D
Mixer/loader	AM, AT, 4D, DP, DC, TB, TC, DE	AT, 4D, DP, DC, GP, TB	AM, AT, CP, 4D, DP, DC, GP, HX, TB, TC, DE, KE	AT, 4D, DP, DC, GP, TB, TC	AM, AT, 4D
Fuel Truck Operator	—	—	4D	AT, DC	—
Backpack Applications					
Applicator	—	—	AM, AT, 4D, DP, TC, DE	AT, 4D, DP, DC, GP	AT, 4D
Ground Mechanical Operations					
Applicator	4D	AT	AM, AT, 4D, DP, DC, GP, TB, TC, DE	AT, 4D, DP, DC, GP, TB, TC	AT, 4D
Mixer/loader	AM, 4D	AT	AM, AT, 4D, DP, DC, TB, TC, DE	AT, 4D, DP, DC, GP, TB	AT, 4D
Applicator/mixer/loader	4D	AT	AM, AT, 4D, DP, DC, GP, TB, TC, DE	AT, 4D, DP, DC, GP, TB, TC	AT, 4D

AM = Amitrole; AT = Atrazine; CP = Clopyralid; 4D = 2,4-D; DP = Dalapon; DC = Dicamba; GP = Glyphosate; HX = Hexazinone; TB = Tebuthiuron; TC = Triclopyr; DE = Diesel; KE = Kerosene.

Amitrole - BLM has reexamined the risk assessment and examined additional data. BLM has determined that amitrole is no longer considered for proposed use in this document. Amitrole will be deleted in the Record of Decision.

Dalapon - Since drafting this document, producers are no longer manufacturing formulations registered for proposed use. Therefore, dalapon is no longer considered for use.

Note: High risks are defined as those exposures that may result in a margin of safety less than 100 or a cancer risk greater than 1-in-1 million.

Table 3-9

High Risks to Members of the Public From Herbicide Use on Public-Domain Forest Land

Exposure Scenario	Typical Exposures		Worst-case Exposures		
	Systemic	Reproductive	Systemic	Reproductive	Cancer
Aerial Applications					
Spray Drift, Dermal	—	—	—	—	—
Vegetation Contact, Hiker	—	—	—	—	—
Vegetation Contact, Picker	—	—	—	—	—
Drinking Water	—	—	AM	—	—
Eating Berries	—	—	—	—	—
Eating Fish	AM	—	AM, 4D	—	—
Hiker	—	—	AM	—	—
Berrypicker	—	—	AM, 4D	AT	—
Angler	AM	—	AM, 4D	—	AM
Nearby Resident	—	—	—	—	—

Table 3-9 (Continued)

High Risks to Members of the Public From Herbicide Use on Public-Domain Forest Land

Exposure Scenario	Typical Exposures		Worst-case Exposures		
	Systemic	Reproductive	Systemic	Reproductive	Cancer
Backpack Applications					
Spray Drift, Dermal	—	—	—	—	—
Vegetation Contact, Hiker	—	—	—	—	—
Vegetation Contact, Picker	—	—	—	—	—
Drinking Water	—	—	AM	—	—
Eating Berries	—	—	—	—	—
Eating Fish	—	—	AM, 4D	—	—
Hiker	—	—	AM	—	—
Berrypicker	—	—	AM	AT	—
Angler	—	—	AM, 4D	AT	—
Nearby Resident	—	—	—	—	—
Ground Mechanical Applications					
Spray Drift, Dermal	—	—	—	—	—
Vegetation Contact, Hiker	—	—	—	—	—
Vegetation Contact, Picker	AM	—	AM, 4D	AT	AM
Drinking Water	—	—	—	—	—
Eating Berries	—	—	—	—	—
Eating Fish	—	—	—	—	—
Hiker	—	—	—	—	—
Berrypicker	AM	—	AM, 4D	AT	AM
Angler	—	—	—	—	—
Nearby Resident	—	—	—	—	—

AM = Amitrole; AT = Atrazine; 4D = 2,4-D

Amitrole - BLM has reexamined the risk assessment and examined additional data. BLM has determined that amitrole is no longer considered for proposed use in this document. Amitrole will be deleted in the Record of Decision.

Note: High risks are defined as those exposures that may result in a margin of safety less than 100 or a cancer risk greater than 1-in-1 million.

Hand Applications. No significant risks of systemic effects, reproductive effects, or cancer are expected for members of the public as a result of hand applications of herbicides to BLM-managed public domain forest land.

Risks to Workers. Routine-realistic exposures of some workers may result in notable systemic risks from atrazine, 2,4-D, or triclopyr; reproductive risks from atrazine or tebuthiuron; and carcinogenic risks from amitrole, atrazine, 2,4-D, or simazine.

Aerial Applications. MOSs are greater than 100 and cancer risks less than 1 in 1 million for workers aerially applying chlorsulfuron, imazapyr, picloram, or kerosene to BLM-managed public domain forest land.

In the routine-realistic case, there are significant risks of adverse systemic effects to pilots from 2,4-D and to mixer-loaders from 2,4-D, or triclopyr. MOSs are all above 100 for fuel truck operators in the realistic case. In the routine-worst case, there are significant systemic risks to pilots from amitrole, atrazine, 2,4-D, dalapon, dicamba, hexazinone, simazine, tebuthiuron, triclopyr, or diesel oil; to mixer-loaders from amitrole, atrazine, 2,4-D, dalapon, dicamba, glyphosate, hexazinone, simazine, tebuthiuron, triclopyr, or diesel oil; and to fuel truck operators from 2,4-D.

In the routine-realistic case, aerial herbicide application to public domain forest land may result in significant reproductive risks from atrazine to pilots and mixer-loaders. Fuel truck operators' MOSs are all above 100 under realistic conditions. In the routine-worst case, there are significant reproductive risks to pilots and mixer-loaders from atrazine, 2,4-D, dalapon, dicamba, glyphosate, simazine, tebuthiuron, or triclopyr and to fuel truck operators from atrazine.

In this scenario, cancer risks exceed 1 in 1 million for pilots from atrazine, 2,4-D, and simazine, and for mixer-loaders from amitrole, atrazine, 2,4-D, and simazine. Cancer risks for fuel truck operators are all less than 1 in 1 million.

Backpack Applications. No significant systemic, reproductive, or cancer risks are predicted for backpack applicators applying herbicides in BLM-managed public domain forest land from chlorsulfuron, imazapyr, picloram, or kerosene.

In the routine-realistic case, backpack applicators have a notable systemic risk from atrazine. In the routine-worst case, there are significant systemic risks from amitrole, atrazine, 2,4-D, dalapon, hexazinone, simazine, triclopyr, and diesel oil.

Reproductive risk is present for applicators in the realistic case from atrazine. In the worst case, high reproductive risks are posed by atrazine, 2,4-D, dalapon, dicamba, glyphosate, simazine, tebuthiuron, and triclopyr.

Significant cancer risks are present for applicators from atrazine, 2,4-D, and simazine.

Ground Mechanical Applications. Workers using ground mechanical equipment to treat BLM-managed public domain forest lands are not expected to have any significant systemic, reproductive, or cancer risks from the use of chlorsulfuron, imazapyr, picloram, or kerosene.

The use of ground mechanical equipment to apply herbicides on public domain forest land results in systemic risks to mixer-loaders and applicator/mixer-loaders from 2,4-D in the routine-realistic case. Using worst case assumptions, significant systemic risks are posed for applicators from amitrole, atrazine, 2,4-D, dalapon, dicamba, glyphosate, hexazinone, simazine, tebuthiuron, triclopyr, and diesel oil and for mixer-loaders and applicator/mixer-loaders from amitrole, atrazine, 2,4-D, dalapon, hexazinone, simazine, tebuthiuron, triclopyr, and diesel oil. In the routine-realistic case, atrazine poses significant reproductive risks for applicators, mixer-loaders, and applicator/mixer-loaders. In the worst case, there are significant reproductive risks for applicators, mixer-loaders, and applicator/mixer-loaders from atrazine, 2,4-D, dalapon, dicamba, glyphosate, simazine, tebuthiuron, and triclopyr.

For ground mechanical treatment of public domain forest lands, worker cancer risks exceed 1 in 1 million for applicators, mixer-loaders, and applicator/mixer-loaders from atrazine, 2,4-D, and simazine.

Hand Applications. The hand applicator on BLM-managed public domain forest land is not expected to face any significant systemic, reproductive, or cancer risks from the use of hexazinone, imazapyr, picloram, or kerosene.

In the routine-realistic case, workers using hand equipment to treat public domain forest land with herbicides may have notable systemic risks from the use of 2,4-D, or triclopyr. In the routine-worst case, systemic risks are high to hand applicators from amitrole, atrazine, chlorsulfuron, 2,4-D, dalapon, simazine, tebuthiuron, triclopyr, or diesel oil.

Routine-realistic reproductive MOSs are less than 100 for hand applicators using atrazine or tebuthiuron. In the worst case, there are high reproductive risks from atrazine, 2,4-D, dalapon, dicamba, glyphosate, simazine, tebuthiuron, and triclopyr.

Cancer risks exceed 1 in 1 million for the hand applicator on public domain forest land from atrazine, 2,4-D, and simazine.

Risks From Oil and Gas Site Herbicide Treatments

Significant risks from herbicide applications on BLM-managed oil and gas sites are presented in Table 3-11 for members of the public and Table 3-12 for workers. The herbicides used on oil and gas sites are amitrole, atrazine, bromacil, chlorsulfuron, clopyralid, 2,4-D, dalapon, dicamba, diuron, glyphosate, hexazinone, imazapyr, mefluidide, metsulfuron methyl, picloram, simazine, sulfometuron methyl, tebuthiuron, and triclopyr, and the carriers diesel oil and kerosene.

Risks to Members of the Public. In the routine-realistic case, no significant systemic, reproductive, or carcinogenic risks are expected for members of the public as a result of herbicide application to oil and gas sites.

Aerial Applications. Routine-realistic aerial applications of herbicides on oil and gas sites are not expected to result in any significant risks of systemic effects to members of the public. Routine-worst case applications may lead to significant risks from diuron as a result of dermal exposure to spray drift, the multiple exposures of a hiker, or the multiple exposures of a nearby resident.

Routine-realistic aerial application to oil and gas sites is not expected to result in any significant reproductive risks to members of the public. However, in the routine-worst case, atrazine presents significant

Table 3-10

High Risks to Workers From Herbicide Use on Public-Domain Forest Land

Exposure Scenario	Typical Exposures		Worst-case Exposures		
	Systemic	Reproductive	Systemic	Reproductive	Cancer
Aerial Applications					
Pilot	4D	AT	AM, AT, 4D, DP, DC, HX, SI, TB, TC, DE	AT, 4D, DP, DC, GP, SI, TB, TC	AT, 4D, SI
Mixer-loader	4D, TC	AT	AM, AT, 4D, DP, DC, GP, HX, SI, TB, TC, DE	AT, 4D, DP, DC, GP, SI, TB, TC	AM, AT, 4D, SI
Fuel Truck Operator	—	—	4D	AT	—
Backpack Applications					
Applicator	—	AT	AM, AT, 4D, DP HX, SI, TC, DE	AT, 4D, DP, DC GP, SI, TB, TC	AT, 4D, SI
Ground Mechanical Operations					
Applicator	4D	AT	AM, AT, 4D, DP, DC, GP, HX, SI, TB, TC, DE	AT, 4D, DP, DC, GP, SI, TB, TC	AT, 4D, SI
Mixer-loader	4D	AT	AM, AT, 4D, DP, HX, SI, TB, TC, DE	AT, 4D, DP, DC, GP, SI, TB, TC	AT, 4D, SI
Applicator/mixer-loader	4D	AT	AM, AT, 4D, DP, HX, SI, TB, TC, DE	AT, 4D, DP, DC, GP, SI, TB, TC	AT, 4D, SI
Hand Applications					
Applicator	4D, TC	AT, TB	AM, AT, CS, 4D, DP SI, TB, TC, DE	AT, 4D, DP, DC, GP, SI, TB, TC	AT, 4D, SI

AM = Amitrole; AT = Atrazine; CS = Chlorsulfuron; 4D = 2,4-D; DP = Dalapon; DC = Dicamba; GP = Glyphosate; HX = Hexazinone; SI = Simazine; TB = Tebuthiuron; TC = Triclopyr; DE = Diesel.

Amitrole - BLM has reexamined the risk assessment and examined additional data. BLM has determined that amitrole is no longer considered for proposed use in this document. Amitrole will be deleted in the Record of Decision.

Dalapon - Since drafting this document, producers are no longer manufacturing formulations registered for proposed use. Therefore, dalapon is no longer considered for use.

Note: High risks are defined as those exposures that may result in a margin of safety less than 100 or a cancer risk greater than 1-in-1 million.

Table 3-11

High Risks to Members of the Public From Herbicide Use on Oil and Gas Sites

Exposure Scenario	Typical Exposures		Worst-case Exposures		
	Systemic	Reproductive	Systemic	Reproductive	Cancer
Aerial Applications					
Spray Drift, Dermal	—	—	DU	AT	—
Vegetation Contact, Hiker	—	—	—	—	—
Hiker	—	—	DU	AT	—
Nearby Resident	—	—	DU	AT	—
Backpack Applications					
Spray Drift, Dermal	—	—	—	—	—
Vegetation Contact, Hiker	—	—	—	—	—
Hiker	—	—	—	—	—
Nearby Resident	—	—	—	—	—

Table 3-11 (Continued)

High Risks to Members of the Public From Herbicide Use on Oil and Gas Sites

Exposure Scenario	Typical Exposures		Worst-case Exposures		
	Systemic	Reproductive	Systemic	Reproductive	Cancer
Ground Mechanical Applications					
Spray Drift, Dermal	—	—	—	—	—
Vegetation Contact, Hiker	—	—	—	—	—
Hiker	—	—	—	—	—
Nearby Resident	—	—	—	—	—

AT = Atrazine; DU = Diuron.

Note: High risks are defined as those exposures that may result in a margin of safety less than 100 or a cancer risk greater than 1-in-1 million.

reproductive risks from dermal exposure to spray drift and the multiple exposures that may be received by a hiker or a nearby resident.

Estimated cancer risk probabilities for members of the public as a result of aerial applications of herbicides on BLM-managed oil and gas sites do not exceed 1 in 1 million.

Backpack Applications. Routine-realistic backpack applications of herbicides on BLM-managed oil and gas sites are not expected to result in any adverse systemic effects for members of the public. No significant reproductive effects for members of the public are expected from routine-realistic backpack applications on oil and gas sites. Cancer risks estimated for members of the public as a result of oil and gas site backpack herbicide application do not exceed 1 in 1 million.

Ground Mechanical Applications. There are no expected significant systemic or reproductive risks to members of the public from ground mechanical herbicide application on BLM-managed oil and gas sites. No cancer risks in this scenario exceed 1 in 1 million.

Hand Applications. There are no expected significant systemic, reproductive, or cancer risks to members of the public from the hand application of herbicides to oil and gas sites.

Risks to Workers. In routine-realistic cases on oil and gas sites, workers may be at risk of systemic effects from applying amitrole, atrazine, bromacil, 2,4-D, dalapon, diuron, mefluidide, metsulfuron methyl, sulfometuron methyl, simazine, or triclopyr; reproductive risks from atrazine, dalapon, diuron, simazine, or tebuthiuron; and carcinogenic effects from amitrole, atrazine, bromacil, 2,4-D, or simazine.

Aerial Applications. Herbicides used in oil and gas site aerial applications for which no worker is estimated to have an MOS less than 100 or cancer risk greater than 1 in 1 million are chlorsulfuron, imazapyr, mefluidide, metsulfuron methyl, picloram, and kerosene.

Routine-realistic aerial application of herbicides to oil and gas sites may cause significant systemic risks to pilots from amitrole, atrazine, diuron, and simazine and to mixer-loaders from amitrole, atrazine, bromacil, 2,4-D, dalapon, diuron, simazine, and triclopyr. There are no significant adverse systemic risks to fuel truck operators in the realistic case. In the routine-worst case, there are significant systemic risks to pilots from amitrole, atrazine, bromacil, clopyralid, 2,4-D, dalapon, dicamba, diuron, hexazinone, simazine, tebuthiuron, triclopyr, and diesel oil; to mixer-loaders from amitrole, atrazine, bromacil, clopyralid, 2,4-D, dalapon, dicamba, diuron, hexazinone, simazine, sulfometuron methyl, tebuthiuron, triclopyr, and diesel oil; and to fuel truck operators from atrazine, and diuron.

Under the routine-realistic case, significant reproductive risks exist for pilots from atrazine, diuron, and simazine and for mixer-loaders from atrazine, dalapon, diuron, simazine, and tebuthiuron. There are no high reproductive risks for fuel truck operators in the realistic case. In the routine-worst case, there are significant risks to pilots from atrazine, bromacil, 2,4-D, dalapon, dicamba, diuron, glyphosate, simazine, tebuthiuron, and triclopyr; to mixer-loaders from atrazine, bromacil, 2,4-D, dalapon, dicamba, diuron, glyphosate, hexazinone, simazine, tebuthiuron, and triclopyr; and to fuel truck operators from atrazine and simazine.

For workers involved in aerial herbicide applications on oil and gas sites, cancer risks are significant for pilots from amitrole, atrazine, 2,4-D, and simazine; for mixer-loaders from amitrole, atrazine, bromacil, 2,4-D, and simazine; and for fuel truck operators from atrazine and simazine.

Backpack Applications. No significant systemic, reproductive, or cancer risks are expected for backpack applicators on oil and gas sites who are applying chlorsulfuron, imazapyr, metsulfuron methyl, picloram, or kerosene.

In the routine-realistic case, backpack applicators on oil and gas sites have significant systemic risks from diuron. In the worst case, they have high systemic risks from amitrole, atrazine, bromacil, clopyralid, 2,4-D, dalapon, dicamba, diuron, hexazinone, mefluidide, simazine, sulfometuron methyl, tebuthiuron, triclopyr, and diesel oil.

Backpack applicators have high reproductive risks from atrazine in the realistic case. In the worst case, reproductive risks are significant from atrazine, bromacil, clopyralid, 2,4-D, dalapon, dicamba, diuron, glyphosate, simazine, tebuthiuron, and triclopyr.

Cancer risks to backpack applicators on oil and gas sites exceed 1 in 1 million for amitrole, atrazine, 2,4-D, and simazine.

Ground Mechanical Applications. No significant systemic, reproductive, or cancer risks are expected for workers using ground mechanical equipment on oil and gas sites to apply chlorsulfuron, imazapyr, metsulfuron methyl, picloram, or kerosene.

Routine-realistic exposures to workers in oil and gas site ground mechanical applications present significant risks of systemic effects to applicators from diuron; to mixer-loaders from atrazine, 2,4-D, and diuron; and to applicator/mixer-loaders from atrazine and diuron. Worst case exposures result in high systemic risks to applicators from amitrole, atrazine, bromacil, clopyralid, 2,4-D, dalapon, dicamba, diuron, hexazinone, mefluidide, simazine, sulfometuron methyl, tebuthiuron, triclopyr, and diesel oil; to mixer-loaders from amitrole, atrazine, bromacil, clopyralid, 2,4-D, dalapon, diuron, hexazinone, simazine, tebuthiuron, and triclopyr; and to applicator/mixer-loaders from amitrole, atrazine, bromacil, clopyralid, 2,4-D, dalapon, diuron, hexazinone, simazine, tebuthiuron, triclopyr, and diesel oil.

Routine-realistic applications present high reproductive risks for applicators from atrazine and for mixer-loaders and applicator/mixer-loaders from atrazine. Worst case applications result in reproductive MOSs less than 100 for applicators from atrazine, bromacil, clopyralid, 2,4-D, dalapon, dicamba, diuron, glyphosate, hexazinone, simazine, tebuthiuron, and triclopyr and for mixer-loaders and applicator/mixer-loaders from atrazine, bromacil, 2,4-D, dalapon, dicamba, diuron, glyphosate, simazine, tebuthiuron, and triclopyr.

Cancer risks exceed 1 in 1 million for oil and gas site ground mechanical operations for applicators from amitrole, atrazine, 2,4-D, and simazine and for mixer-loaders and applicator/mixer-loaders from amitrole, atrazine, and simazine.

Hand Applications. Systemic, reproductive, and cancer risk estimates for workers in oil and gas site hand applications do not exceed the risk criteria as a result of applying clopyralid, hexazinone, imazapyr, picloram, and kerosene.

Hand herbicide application on oil and gas sites may result in high systemic risk to applicators from the use of 2,4-D, diuron, mefluidide, sulfometuron methyl, or triclopyr in the routine-realistic case. In the worst case, hand applicators have a significant systemic risk from amitrole, atrazine, bromacil, chlorsulfuron, 2,4-D, dalapon, diuron, mefluidide, sulfometuron methyl, tebuthiuron, triclopyr, and diesel oil.

Routine-realistic reproductive MOSs are less than 100 for atrazine and tebuthiuron. In the worst case, there are notable reproductive risks from atrazine, bromacil, 2,4-D, dalapon, dicamba, diuron, glyphosate, simazine, tebuthiuron, and triclopyr.

Cancer risks to the hand applicator treating oil and gas sites are high from atrazine, 2,4-D, and simazine.

Risks From Right-of-Way Herbicide Treatments

MOSs that are less than 100 and cancer risks that are greater than 1 in 1 million as a result of herbicide applications on rights-of-way are presented in Table 3-13 for members of the public and Table 3-14 for workers. Herbicides used on rights-of-way are amitrole, atrazine, bromacil, chlorsulfuron, clopyralid, 2,4-D, dalapon, dicamba, diuron, glyphosate, hexazinone, imazapyr, mefluidide, metsulfuron methyl, picloram, simazine, sulfometuron methyl, tebuthiuron, and triclopyr; the carriers diesel oil and kerosene also are used.

Risks to Members of the Public. In the routine-realistic case, members of the public may be at risk of systemic effects and carcinogenicity from amitrole.

Aerial Applications. For routine-realistic aerial applications on BLM-managed rights-of-way, risks of systemic effects for members of the public are significant for eating fish from a body of water contaminated with amitrole spray drift and for the multiple exposures that an angler may receive from amitrole. In the routine-worst case, there are high risks from dermal exposure to spray drift from diuron; the veg-

Table 3-12

High Risks to Workers From Herbicide Use on Oil and Gas Sites

Exposure Scenario	Typical Exposures		Worst-case Exposures		
	Systemic	Reproductive	Systemic	Reproductive	Cancer
Aerial Applications					
Pilot	AM, AT, DU, SI	AT, DU, SI	AM, AT, BR, CP, 4D, DP, DC, DU, HX, SI, TB, TC, DE	AT, BR, 4D, DP, DC, DU, GP, SI, TB, TC	AM, AT, 4D, SI
Mixer-loader	AM, AT, BR, 4D, DP, SI, TC	AT, DP, DU, SI, TB	AM, AT, BR, CP, 4D, DP, DC, DU, HX, SI, SM, TB, TC, DE	AT, BR, 4D, DP, DC, DU, GP, SI, TB, TC	AM, AT, BR, 4D, SI
Fuel Truck Operator	—	—	AT, DU, SI	AT, SI	AT, SI
Backpack Applications					
Applicator	DU	AT	AM, AT, BR, CP, 4D DP, DC, DU, HX, MF, SM, TB, TC, DE	AT, BR, CP, 4D, DP, DC, DU, GP,TB, TC	AM, AT, 4D, SI
Ground Mechanical Operations					
Applicator	DU	AT	AM, AT, BR, CP, 4D, DP, DC, DU, HX, MF, SI, SM, TB, TC, DE	AT, BR, CP, 4D, DC, DP, DU, GP, HX, SI, TB, TC	AM, AT, 4D, SI
Mixer-loader	AT, 4D, DU	AT	AM, AT, BR, CP, 4D, DP, DU, HX, SI, TB, TC	AT, BR, 4D, DP, DC, DU, SI, TB, TC	AM, AT, SI
Applicator/mixer-loader	AT, DU	AT	AM, AT, BR, CP, 4D, DP, DU, HX, SI, TB, TC, DE	AT, BR, 4D, DP, DC, DU, GP, SI, TB, TC	AM, AT, SI
Hand Applications					
Applicator	4D, DU, MF, SM, TC	AT, TB	AM, AT, BR, CS, 4D, DP, DU, MF, SI, SM, TB, TC, DE	AT, BR, 4D, DP, DC, DU, GP, SI, TB, TC	AT, 4D, SI

AM = Amitrole; AT = Atrazine; BR = Bromacil; CS = Chlorsulfuron; CP = Clopyralid; 4D = 2,4-D; DP = Dalapon; DC = Dicamba; DU = Diuron; GP = Glyphosate; HX = Hexazinone; MF = Mefluidide; SI = Simazine; SM = Sulfometuron methyl; TB = Tebuthiuron; TC = Triclopyr; DE = Diesel.

Amitrole - BLM has reexamined the risk assessment and examined additional data. BLM has determined that amitrole is no longer considered for proposed use in this document. Amitrole will be deleted in the Record of Decision.

Dalapon - Since drafting this document, producers are no longer manufacturing formulations registered for proposed use. Therefore, dalapon is no longer considered for use.

Note: High risks are defined as those exposures that may result in a margin of safety less than 100 or a cancer risk greater than 1-in-1 million.

Table 3-13

High Risks to Members of the Public From Herbicide Use on Rights-of-Way

Exposure Scenario	Typical Exposures		Worst-case Exposures		
	Systemic	Reproductive	Systemic	Reproductive	Cancer
Aerial Applications					
Spray Drift, Dermal	—	—	DU	AT	—
Vegetation Contact, Hiker	—	—	—	—	—
Vegetation Contact, Picker	—	—	DU	AT	—
Drinking Water	—	—	AM, DU	AT	—
Eating Berries	—	—	AM	—	—
Eating Fish	AM	—	AM, DU	AT	AM
Hiker	—	—	AM, DU	AT	—
Berrypicker	—	—	AM, AT, DU	AT	—
Angler	AM	—	AM, AT, 4D, DU	AT, DU, SI	AM
Nearby Resident	—	—	DU	AT	—

Table 3-13 (Continued)

High Risks to Members of the Public From Herbicide Use on Rights-of-Way

	Typical Exposures		Worst-case Exposures		
Exposure Scenario	Systemic	Reproductive	Systemic	Reproductive	Cancer
Backpack Applications					
Spray Drift, Dermal	—	—	—	—	—
Vegetation Contact, Hiker	—	—	—	—	—
Vegetation Contact, Picker	—	—	DU	AT	—
Drinking Water	—	—	—	—	—
Eating Berries	—	—	—	—	—
Eating Fish	—	—	—	—	—
Hiker	—	—	—	—	—
Berrypicker	—	—	DU	AT	—
Angler	—	—	—	—	—
Nearby Resident	—	—	—	—	—
Ground Mechanical Applications					
Spray Drift, Dermal	—	—	—	—	—
Vegetation Contact, Hiker	—	—	—	—	—
Vegetation Contact, Picker	AM	—	AM, AT, DU	AT	AM
Drinking Water	—	—	—	—	—
Eating Berries	—	—	—	—	—
Eating Fish	—	—	AM	—	—
Hiker	—	—	—	—	—
Berrypicker	AM	—	AM, AT, DU	AT	AM
Angler	—	—	AM	—	—
Nearby Resident	—	—	—	—	—

AM = Amitrole; AT = Atrazine; 4D = 2,4-D; DU = Diuron; SI = Simazine.

Amitrole - BLM has reexamined the risk assessment and examined additional data. BLM has determined that amitrole is no longer considered for proposed use in this document. Amitrole will be deleted in the Record of Decision.

Note. High risks are defined as those exposures that may result in a margin of safety less than 100 or a cancer risk greater than 1-in-1 million.

etation contact of a berrypicker from diuron; drinking water that has received spray drift from amitrole, and diuron; the eating of berries contaminated with drift from amitrole; the eating of fish from a body of water contaminated with spray drift from amitrole, and diuron; the multiple exposures a hiker may receive from amitrole, and diuron; the multiple exposures a berrypicker may receive from amitrole, atrazine, and diuron; the multiple exposures an angler may receive from amitrole, atrazine, 2,4-D, and diuron; and the multiple exposures a nearby resident may receive from diuron.

Reproductive risk estimates result in MOSs greater than 100 for all herbicides in the routine-realistic case. In the routine-worst case, significant risks are expected for dermal exposure to spray drift from atrazine; vegetation contact by a berrypicker from atrazine; drinking water that has been contaminated with spray drift from atrazine; the eating of fish from a body of water that has received spray drift from atrazine; the multiple exposures a hiker or nearby resident may have to atrazine; the multiple exposures a berrypicker may have to atrazine; and the multiple exposures an angler may have to atrazine, and diuron.

Cancer risks are significant for eating fish from a body of water that has been contaminated with amitrole spray drift and the multiple exposures that an angler may receive from amitrole.

Backpack Applications. Risks of systemic effects to members of the public from backpack applications on rights-of-way all have MOSs greater than 100 in the routine-realistic case. In the routine-worst case, there are significant systemic risks from diuron for a berrypicker from vegetation contact and the multiple exposures of a berrypicker.

There are no significant reproductive risks to members of the public from routine-realistic backpack applications on rights-of-way. For routine-worst case applications, there is expected to be a significant risk from atrazine for vegetation contact for a berrypicker and the multiple exposures of a berrypicker.

No cancer risk estimate for members of the public exceeds 1 in 1 million for backpack herbicide applications on rights-of-way.

Ground Mechanical Applications. The routine-realistic dose estimated for vegetation contact by a berrypicker results in a significant risk of systemic effects from amitrole, as do the multiple exposures received by a berrypicker. In the routine-worst case, there is a significant risk of systemic effects from vegetation contact by a berrypicker from amitrole, atrazine, and diuron; the eating of fish from a body of water that has been contaminated with amitrole spray drift; multiple exposures to a berrypicker from amitrole, atrazine, and diuron; and the multiple exposures an angler may have from amitrole.

Routine-realistic exposures are not expected to result in any adverse reproductive effects to members of the public from ground mechanical herbicide applications. However, in the routine-worst case, there are significant reproductive risks from vegetation contact by a berrypicker and the multiple exposures of a berrypicker from atrazine.

Cancer risks exceed 1 in 1 million for vegetation contact by a berrypicker and the multiple exposures of a berrypicker from amitrole.

Risks to Workers. In the routine-realistic case, workers on rights-of-way may be at risk of systemic effects from applying amitrole, atrazine, bromacil, 2,4-D, dalapon, diuron, mefluidide, metsulfuron methyl, sulfometuron methyl, simazine, or triclopyr; reproductive effects from atrazine, dalapon, diuron, simazine, or tebuthiuron; and increased cancer risk from amitrole, atrazine, bromacil, 2,4-D, or simazine.

Aerial Applications. MOSs are greater than 100 and cancer risks less than 1 in 1 million for all rights-of-way aerial workers applying chlorsulfuron, imazapyr, metsulfuron methyl, and picloram.

Routine-realistic aerial applications to rights-of-way result in significant systemic risks to pilots from amitrole, atrazine, diuron, and simazine, and to mixer-loaders from amitrole, atrazine, bromacil, 2,4-D, dalapon, diuron, simazine, and triclopyr. There are no high systemic risks in the realistic case to fuel truck operators. In the routine-worst case, there are notable systemic risks to pilots from amitrole, atrazine, bromacil, clopyralid, 2,4-D, dalapon, dicamba, diuron, glyphosate, hexazinone, mefluidide, simazine, sulfometuron methyl, tebuthiuron, triclopyr, and diesel oil; to mixer-loaders from amitrole, atrazine, bromacil, clopyralid, 2,4-D, dalapon, dicamba, diuron, glyphosate, hexazinone, mefluidide, simazine, sulfometuron methyl, tebuthiuron, triclopyr, diesel oil, and kerosene; and to fuel truck operators from amitrole, atrazine, dalapon, diuron, and triclopyr.

Reproductive risks in the realistic case are significant for pilots from atrazine, diuron, and simazine and for mixer-loaders from atrazine, dalapon, diuron, simazine, and tebuthiuron. There are no significant reproductive risks to fuel truck operators in the realistic case. In the worst case, there are high reproductive risks to pilots and mixer-loaders from atrazine, bromacil, clopyralid, 2,4-D, dalapon, dicamba, diuron, glyphosate, hexazinone, simazine, tebuthiuron, and triclopyr and to fuel truck operators from atrazine, diuron, and tebuthiuron.

There are significant cancer risks for pilots and mixer-loaders from amitrole, atrazine, bromacil, 2,4-D, and simazine and for fuel truck operators from atrazine and simazine.

Backpack Applications. Risk estimates for backpack applicators on rights-of-way do not exceed the systemic, reproductive, or cancer risk criteria as a result of the use of chlorsulfuron, imazapyr, mefluidide, metsulfuron methyl, picloram, or kerosene.

Backpack applicators receiving routine-realistic exposures on rights-of-way are expected to have significant systemic risks from diuron. In the worst case, high risks result from the use of amitrole, atrazine, bromacil, clopyralid, 2,4-D, dalapon, diuron, hexazinone, simazine, sulfometuron methyl, triclopyr, and diesel oil.

Excess reproductive risks to backpack applicators on rights-of-way may result from atrazine under realistic conditions. In the worst case, there may be high reproductive risks from atrazine, bromacil, 2,4-D, dalapon, dicamba, diuron, glyphosate, simazine, tebuthiuron, and triclopyr.

There are significant cancer risks to backpack applicators treating rights-of-way with atrazine, 2,4-D, and simazine.

Ground Mechanical Applications. MOSs are all greater than 100 and cancer risks less than 1 in 1 million for ground mechanical workers on rights-of-way for applications of chlorsulfuron, imazapyr, metsulfuron methyl, picloram, and kerosene.

Routine-realistic ground mechanical applications of herbicides on rights-of-way may lead to significant systemic risks to applicators from diuron and to mixer-loaders and applicator/mixer-loaders from 2,4-D, and diuron. Worst case applications may cause high systemic risks to applicators from amitrole, atrazine, bromacil, clopyralid, 2,4-D, dalapon, dicamba, diuron, hexazinone, mefluidide, simazine, sulfometuron methyl, tebuthiuron, triclopyr, and diesel oil; to mixer-loaders from amitrole, atrazine, bromacil, clopyralid, 2,4-D, dalapon, diuron, hexazinone, simazine, tebuthiuron, and triclopyr; and to applicator/mixer-loaders from amitrole, atrazine, bromacil, clopyralid, 2,4-D, dalapon, diuron, hexazinone, simazine, tebuthiuron, triclopyr, and diesel oil.

In the routine-realistic case, significant reproductive risks are posed for applicators from atrazine and for mixer-loaders and applicator/mixer-loaders from atrazine. In the worst case, there are notable reproductive risks for applicators from atrazine, bromacil, clopyralid, 2,4-D, dalapon, dicamba, diuron, glyphosate, hexazinone, simazine, tebuthiuron, and triclopyr and for mixer-loaders and applicator/mixer-loaders from atrazine, bromacil, 2,4-D, dalapon, dicamba, diuron, glyphosate, simazine, tebuthiuron, and triclopyr.

Significant cancer risks are present for applicators and applicator/mixer-loaders from amitrole, atrazine, 2,4-D, and simazine and for mixer-loaders from atrazine and simazine.

Hand Applications. There are no excessive systemic, reproductive, or cancer risks to hand applicators from the use of clopyralid, hexazinone, imazapyr, picloram, or kerosene on rights-of-way.

Workers applying herbicides by hand equipment on rights-of-way are at systemic risk from 2,4-D, diuron, mefluidide, sulfometuron methyl, and triclopyr in the routine-realistic case. Under worst case assumptions, applicators are at high systemic risk from amitrole, atrazine, bromacil, chlorsulfuron, 2,4-D, dalapon, diuron, mefluidide, simazine, sulfometuron methyl, tebuthiuron, triclopyr, and diesel oil.

Realistic exposures may result in excess reproductive risks from atrazine and tebuthiuron. Worst case exposures may lead to significant reproductive risks from atrazine, bromacil, 2,4-D, dalapon, dicamba, diuron, glyphosate, simazine, tebuthiuron, and triclopyr.

Cancer risks to hand applicators on rights-of-way exceed 1 in 1 million for atrazine, 2,4-D, and simazine.

Risks From Public Recreation and Cultural Site Herbicide Treatments

Risks from herbicide applications on public recreation and cultural sites are summarized in Table 3-15 for members of the public and Table 3-16 for workers. The herbicides used on public recreation and cultural sites are atrazine, chlorsulfuron, 2,4-D, dalapon, dicamba, glyphosate, hexazinone, imazapyr, picloram, simazine, tebuthiuron, triclopyr; the carriers diesel oil and kerosene also are used.

Table 3-14

High Risks to Workers From Herbicide Use on Rights-of-Way

	Typical Exposures		Worst-case Exposures		
Exposure Scenario	**Systemic**	**Reproductive**	**Systemic**	**Reproductive**	**Cancer**
Aerial Applications					
Pilot	AM, AT, DU, SI	AT, DU, SI	AM, AT, BR, CP, 4D, DP, DC, DU, GP, HX, MF, SI, SM, TB, TC, DE	AT, BR, CP, 4D, DP, DC, DU, GP, HX, SI, TB, TC	AM, AT, BR, 4D, SI
Mixer-loader	AM, AT, BR, 4D, DP, DU, SI, TC	AT, DP, DU, SI, TB	All except CS, IP, MM, PC	AT, BR, CP, 4D, DP, DC, DU, GP, HX, SI, TB, TC	AM, AT, BR, 4D, SI
Fuel Truck Operator	—	—	AM, AT, DP, DU, TC	AT, DU, TB	AT, SI
Backpack Applications					
Applicator	DU	AT	AM, AT, BR, CP, 4D, DP, DU, HX, SI, SM, TC, DE	AT, BR, 4D, DP, DC, DU, GP, SI, TB, TC	AT, 4D, SI
Ground Mechanical Operations					
Applicator	DU	AT	AM, AT, BR, CP, 4D, DP, DC, DU, HX, MF, SI, SM, TB, TC, DE	AT, BR, CP, 4D, DP, DC, DU, GP, HX, SI, TB, TC	AM, AT, 4D, SI
Mixer-loader	4D, DU	AT	AM, AT, BR, CP, 4D, DP, DU, HX, SI, TB, TC	AT, BR, 4D, DP, DC, DU, GP, SI, TB, TC	AT, SI
Applicator/mixer-loader	4D, DU	AT	AM, AT, BR, CP, 4D, DP, DU, HX, SI, TB, TC, DE	AT, BR, 4D, DP DC, DU, GP, SI, TB, TC	AM, AT, 4D, SI

Table 3-14 (Continued)

High Risks to Workers From Herbicide Use on Rights-of-Way

Exposure Scenario	Typical Exposures: Systemic	Typical Exposures: Reproductive	Worst-case Exposures: Systemic	Worst-case Exposures: Reproductive	Worst-case Exposures: Cancer
Hand Applications					
Applicator	4D, DU, MF, MM, SM, TC	AT, TB	AM, AT, BR, CS, 4D, DP, DU, MF, MM, SM, TB, TC, DE	AT, BR, 4D, DP, DC, DU, GP, SM, TB, TC	AT, 4D, SI

AM = Amitrole; AT = Atrazine; BR = Bromacil; CS = Chlorsulfuron; CP = Clopyralid; 4D = 2,4-D; DP = Dalapon; DC = Dicamba; DU = Diuron; GP = Glyphosate; HX = Hexazinone; IP = Imazapyr; MF = Mefluidide; MM = Metsulfuron methyl; PC = Picloram; SI = Simazine; SM Sulfometuron methyl; TB Tebuthiuron; TC = Triclopyr; DE = Diesel; KE = Kerosene.

Amitrole - BLM has reexamined the risk assessment and examined additional data. BLM has determined that amitrole is no longer considered for proposed use in this document. Amitrole will be deleted in the Record of Decision.

Dalapon - Since drafting this document, producers are no longer manufacturing formulations registered for proposed use. Therefore, dalapon is no longer considered for use.

Note: High risks are defined as those exposures that may result in a margin of safety less than 100 or a cancer risk greater than 1-in-1 million.

Table 3-15

High Risks to Members of the Public From Herbicide Use on Recreation and Cultural Sites

Exposure Scenario	Typical Exposures: Systemic	Typical Exposures: Reproductive	Worst-case Exposures: Systemic	Worst-case Exposures: Reproductive	Worst-case Exposures: Cancer
Backpack Applications					
Spray Drift, Dermal	—	—	—	—	—
Vegetation Contact, Hiker	—	—	—	—	—
Vegetation Contact, Picker	—	—	—	—	—
Drinking Water	—	—	—	—	—
Eating Berries	—	—	—	—	—
Eating Fish	—	—	—	—	—
Hiker	—	—	—	—	—
Berrypicker	—	—	—	—	—
Angler	—	—	—	—	—
Nearby Resident	—	—	—	—	—
Ground Mechanical Applications					
Spray Drift, Dermal	—	—	—	—	—
Vegetation Contact, Hiker	—	—	—	—	—
Vegetation Contact, Picker	—	—	—	—	—
Drinking Water	—	—	—	—	—
Eating Berries	—	—	—	—	—
Eating Fish	—	—	—	—	—
Hiker	—	—	—	—	—
Berrypicker	—	—	—	—	—
Angler	—	—	—	—	—
Nearby Resident	—	—	—	—	—

Note. High risks are defined as those exposures that may result in a margin of safety less than 100 or a cancer risk greater than 1-in-1 million.

Risks to Members of the Public. No significant systemic, reproductive, or carcinogenic risks are expected for members of the public as a result of herbicide applications to public recreation and cultural sites in the routine-realistic case.

Aerial Applications. BLM does not use aerial applications on public recreation and cultural sites.

Backpack Applications. There are no expected significant systemic, reproductive, or cancer risks to members of the public from backpack application of herbicides on BLM-managed public recreation and cultural sites.

Ground Mechanical Applications. There are no expected significant systemic, reproductive, or cancer risks to members of the public from ground mechanical application of herbicides on BLM-managed public recreation and cultural sites.

Hand Applications. There are no expected significant systemic, reproductive, or cancer risks to members of the public from hand application of herbicides on BLM-managed public recreation and cultural sites.

Risks to Workers. Some workers may be at risk of systemic effects from the use of atrazine, 2,4-D, or triclopyr; of reproductive effects from the use of atrazine or tebuthiuron; and of increased carcinogenic effects from the use of atrazine, 2,4-D, or simazine.

Aerial Applications. Aerial applications are not used on BLM-managed public recreation and cultural sites.

Backpack Applications. There are no significant risks to backpack applicators on BLM-managed public recreation and cultural sites from the use of chlorsulfuron, imazapyr, picloram, tebuthiuron, and kerosene.

Systemic MOSs are greater than 100 for all herbicides in the routine-realistic case. Under worst case assumptions, there are significant systemic risks from atrazine, 2,4-D, dalapon, hexazinone, simazine, triclopyr, and diesel oil.

Reproductive MOSs are greater than 100 for all herbicides in the routine-realistic case. Under worst case assumptions, there are significant reproductive risks from atrazine, 2,4-D, dalapon, dicamba, glyphosate, and simazine.

Cancer risks for backpack applicators exceed 1 in 1 million for atrazine and simazine.

Ground Mechanical Applications. The use of ground mechanical applications on BLM-managed public recreation and cultural sites is not expected to result in significant systemic, reproductive, or cancer risks to workers from the use of chlorsulfuron, hexazinone, imazapyr, picloram, diesel oil, or kerosene.

Systemic MOSs are greater than 100 for all herbicides in the routine-realistic case. Under worst case assumptions, there are significant risks of systemic effects for applicators from 2,4-D, dalapon, simazine, and triclopyr; to mixer-loaders from 2,4-D; and to applicator/mixer-loaders from 2,4-D, and simazine.

Reproductive MOSs are greater than 100 for all herbicides in the routine-realistic case. Under worst case assumptions, there are significant risks of systemic effects for applicators from atrazine, dicamba, glyphosate, simazine, and tebuthiuron; to mixer-loaders from atrazine and dicamba; and to applicator/mixer-loaders from atrazine, dicamba, simazine, and tebuthiuron.

Cancer risks exceed 1 in 1 million for applicators and applicator/mixer-loaders from atrazine and simazine and for mixer-loaders from atrazine.

Hand Applications. MOSs are greater than 100 and cancer risks less than 1 in 1 million for hand application workers on public recreation and cultural sites from the use of hexazinone, imazapyr, picloram, and kerosene.

Routine-realistic hand equipment applications may lead to significant systemic risks for applicators from 2,4-D, and triclopyr. Worst case applications are estimated to result in systemic risks from atrazine, chlorsulfuron, 2,4-D, dalapon, simazine, tebuthiuron, triclopyr, and diesel oil.

Routine-realistic reproductive risks for hand applicators are significant from atrazine and tebuthiuron. In the worst case, high risks result from atrazine, 2,4-D, dalapon, dicamba, glyphosate, simazine, tebuthiuron, and triclopyr.

Excess cancer risks are predicted to result from the use of atrazine, 2,4-D, and simazine.

Risks From Accidents

Several accident scenarios were evaluated to estimate the risks that may result from a spill of herbicide concentrate or mixture, the drinking of water or the eating of fish from a body of water that was directly sprayed, immediate reentry to a treated

area, the eating of berries that were directly sprayed, or the drinking of water from a body of water contaminated by a helicopter jettison or batch truck accident. In most cases, MOSs and cancer risks are significant. Risks are summarized in Tables 3-17 to 3-21 for the five program areas. Standard operating procedures and safety precautions will minimize the potential for accidents such as these to occur.

Risk of Heritable Mutations

Three of the herbicides examined in this EIS—atrazine, diuron, and simazine—have demonstrated a potential to cause mutagenic changes in various laboratory test systems. It is possible that these herbicides may cause heritable mutations in mammals. Diesel oil and kerosene also may present a risk of mutagenic effects, because they contain PAHs and other constituents that are known or suspected mutagens.

Bromacil, 2,4-D, glyphosate, and picloram have not clearly demonstrated any mutagenic potential. However, they are considered to be potential carcinogens in this risk assessment. Because there is a possible correlation between mutagenicity and carcinogenicity, these herbicides may cause genetic damage if the mechanism of their carcinogenicity is related to genetic damage.

The rest of the herbicides have not sufficiently demonstrated any mutagenic or carcinogenic potential. Therefore, they are considered to present a negligible risk of heritable mutations.

Risk of Synergistic Effects

The likelihood seems minimal that synergistic effects will occur in any of BLM's vegetation treatments with herbicides. Exposure to more than one herbicide would be limited to those instances where a mixture is used. Those mixtures that would be used in the program are tested and approved by EPA. There is a possibility that long-term effects could occur from the use of these mixtures and that the EPA testing was not sufficient to detect these effects. The probability of long-term synergistic effects from herbicide mixtures, their kind and magnitude, are not predictable based on the current state of scientific knowledge and testing. Based on experience with herbicide mixture use to date, however, it would seem that the probability of long-term synergistic effects would be very low.

Effects of Inert Ingredients

Most pesticide formulations contain inert ingredients, in addition to the active ingredient. These inert ingredients act as solvents or carriers, help maintain the stability of the formulation, or increase the effectiveness of the active ingredient after application. An inert ingredient is not necessarily chemically unreactive; it is simply not an active ingredient in the formulation. EPA's Office of Pesticides and Toxic Substances (EPA 1989) has identified about 1,200 inert ingredients used in pesticides, and they have categorized these chemicals based on their ability to cause chronic human effects as follows:

List 1—Inerts of Toxicological Concern: Fifty-seven chemicals shown to be carcinogens, developmental toxicants, neurotoxins, or exhibiting potential ecological hazards that merit higher priority for regulatory action.

List 2—Inerts With a High Priority for Testing: Sixty-nine chemicals with data suggesting, but not confirming, possible chronic health effects or having chemical structures similar to chemicals on List 1.

List 3—Inerts of Unknown Toxicity: All chemicals for which there is no basis for inclusion on Lists 1, 2, or 4.

List 4—Minimum Risk Inerts: Two hundred seventy-seven chemicals generally regarded as safe.

Generally, the identity of the inerts present in a given formulation is the proprietary information of the manufacturer. For this reason, any potential risks associated with the presence of inert ingredients in the BLM herbicide formulations are unable to be assessed, with the exception of kerosene, which may be present in formulations of 2,4-D and triclopyr esters. This is regarded as a data gap in this EIS. Because there may be hazards associated with inert ingredients in pesticides, BLM generally will use no formulations in the proposed vegetation treatment program that contain inert ingredients on Lists 1 or 2, to reduce the possibility of hazards to human health or ecological resources. The exceptions are Esteron 99 and Garlon 4. These may be used in a limited degree.

Table 3-16

High Risks to Workers From Herbicide Use on Recreation and Cultural Sites

Exposure Scenario	Typical Exposures		Worst-case Exposures		
	Systemic	Reproductive	Systemic	Reproductive	Cancer
Backpack Applications					
Applicator	—	—	AT, 4D, DP, HX, SI, TC, DE	AT, 4D, DP, DC, GP, SI	AT, SI
Ground Mechanical Operations					
Applicator	—	—	4D, DP, SI, TC	AT, DC, GP, SI, TB	AT, SI
Mixer-loader	—	—	4D	AT, DC	AT
Applicator/mixer-loader	—	—	4D, SI	AT, DC, SI, TB	AT, SI
Hand Applications					
Applicator	4D, TC	AT, TB	AT, CS, 4D, DP, SI, TB, TC, DE	AT, 4D, DP, DC, GP, SI, TB, TC	AT, 4D, SI

AT = Atrazine; CS = Chlorsulfuron; 4D = 2,4-D; DP = Dalapon; DC = Dicamba; GP = Glyphosate; HX = Hexazinone; SI = Simazine; TB = Tebuthiuron; TC = Triclopyr; DE = Diesel.

Dalapon - Since drafting this document, producers are no longer manufacturing formulations registered for proposed use. Therefore, dalapon is no longer considered for use.

Note: High risks are defined as those exposures that may result in a margin of safety less than 100 or a cancer risk greater than 1-in-1 million.

Table 3-17

High Risks From Accidents From Herbicide Use on Rangeland

Exposure Scenario	Systemic	Reproductive	Cancer
Skin Spill, Concentrate	AM, AT, CP, 4D, DC, GP, HX, IP, PC, TC, DE, KE	AM, AT, CP, 4D, DC, GP, HX, IP, PC, TC, DE, KE	AM, AT, 4D
Skin Spill, Mixture	AM, AT, CP, 4D, DP, DC, GP, HX, IP, PC, TB, TC, DE, KE	AM, AT, CP, 4D, DP, DC, GP, HX, IP, PC, TB, TC, DE, KE	AM, AT, 4D
Direct Spray, Person	AM, AT, 4D, DP, DC, TB, TC	AT, 4D, DC, GP, TB, DE	—
Drinking Directly Sprayed Water	AM, 4D	—	—
Eating Fish From Directly Sprayed Water	AM, 4D, TC	4D, DC	AM
Immediate Reentry, Hiker	—	—	—
Immediate Reentry, Picker	AM, AT, 4D, DP, DC GP, TB, TC, DE	AT, 4D, DP, DC, GP, TB, TC	—

Table 3-17 (Continued)

High Risks From Accidents From Herbicide Use on Rangeland

Exposure Scenario	Systemic	Reproductive	Cancer
Eating Directly Sprayed Berries	AM, AT, 4D	AT, 4D, DC, TB	AM
Drinking Water Contaminated by a Jettison of Mixture	AM, AT, 4D, DP, DC, PC, TB, TC, DE	AM, AT, 4D, DP, DC, GP, TB	AM
Drinking Water Contaminated by a Truck Spill	AM, AT, CP, 4D, DP, DC, GP, HX, PC, TB, TC, DE, KE	AM, AT, 4D, DP, DC, GP, HX, PC, TB, TC	AM, AT, 4D

AM = Amitrole; AT = Atrazine; CP = Clopyralid; 4D = 2,4-D; DP = Dalapon; DC = Dicamba; GP = Glyphosate; HX = Hexazinone; IP = Imazapyr; PC = Picloram; TB = Tebuthiuron; TC = Triclopyr; DE = Diesel; KE = Kerosene.

Amitrole - BLM has reexamined the risk assessment and examined additional data. BLM has determined that amitrole is no longer considered for proposed use in this document. Amitrole will be deleted in the Record of Decision.

Dalapon - Since drafting this document, producers are no longer manufacturing formulations registered for proposed use. Therefore, dalapon is no longer considered for use.

Note: High risks are defined as those exposures that may result in a margin of safety less than 100 or a cancer risk greater than 1-in-1 million.

Table 3-18

High Risks From Accidents From Herbicide Use on Public-Domain Forest Land

Exposure Scenario	Systemic	Reproductive	Cancer
Skin Spill, Concentrate	AM, AT, CS, 4D, DC, GP, HX, IP, PC, SI, TC, DE, KE	AM, AT, CS, 4D, DC, GP, HX, IP, PC, SI, TC, DE, KE	AM, AT, 4D, SI
Skin Spill, Mixture	AM, AT, CS, 4D, DP, DC, GP, HX, IP, PC, SI, TB, TC, DE, KE	AM, AT, CS, 4D, DP, DC, GP, HX, IP, PC, SI, TB, TC, DE, KE	AM, AT, 4D, SI
Direct Spray, Person	AM, AT, 4D, DP, DE HX, SI, TB, TC	AT, 4D, DP, DC, GP, SI, TB, TC	AT
Drinking Directly Sprayed Water	AM, AT, 4D	AT	—
Eating Fish From Directly Sprayed Water	AM, AT, 4D, SI, TC	AT, 4D, DC, SI	AM
Immediate Reentry, Hiker	—	—	—
Immediate Reentry, Picker	AM, AT, 4D, DP, DC, GP, HX, SI, TB, TC, DE	AT, 4D, DP, DC, GP, SI, TB, TC	AT, SI
Eating Directly Sprayed Berries	AM, AT, 4D, SI, TC	AT, 4D, DC, SI, TB	AM
Drinking Water Contaminated by a Jettison of Mixture	AM, AT, 4D, DP, DC, HX, PC, SI, TB, TC, DE	AM, AT, 4D, DP, DC, GP, SI, TB, TC	AM, AT
Drinking Water Contaminated by a Truck Spill	AM, AT, CS, 4D, DP, DC, GP, HX, PC, SI, TB, TC, DE, KE	AM, AT, 4D, DP, DC, GP, HX, PC, SI, TB, TC	AM, AT, 4D, SI

AM = Amitrole; AT = Atrazine; CS = Chlorsulfuron; 4D = 2,4-D; DP = Dalapon; DC = Dicamba; GP = Glyphosate; HX = Hexazinone; IP = Imazapyr; PC = Picloram; SI = Simazine; TB = Tebuthiuron; TC = Triclopyr; DE = Diesel; KE = Kerosene.

Amitrole - BLM has reexamined the risk assessment and examined additional data. BLM has determined that amitrole is no longer considered for proposed use in this document. Amitrole will be deleted in the Record of Decision.

Dalapon - Since drafting this document, producers are no longer manufacturing formulations registered for proposed use. Therefore, dalapon is no longer considered for use.

Note: High risks are defined as those exposures that may result in a margin of safety less than 100 or a cancer risk greater than 1-in-1 million.

Table 3-19

High Risks From Accidents From Herbicide Use on Oil and Gas Sites

Exposure Scenario	Systemic	Reproductive	Cancer
Skin Spill, Concentrate	All except DP, TB	All, except DP, TB	AM, AT, BR, 4D, SI
Skin Spill, Mixture	All	All	AM, AT, BR, 4D, SI
Direct Spray, Person	AM, AT, BR, CP, 4D, DP, DC, DU, HX, SI, TB, TC, DE	AT, BR, 4D, DP, DC, DU, GP, SI, TB, TC	AT, SI
Drinking Directly Sprayed Water	—	—	—
Eating Fish From Directly Sprayed Water	—	—	—
Immediate Reentry, Hiker	AT, DU	AT	—
Immediate Reentry, Picker	—	—	—
Eating Directly Sprayed Berries	—	—	—
Drinking Water Contaminated by a Jettison of Mixture	—	—	—
Drinking Water Contaminated by a Truck Spill	All except imazapyr	AM, AT, BR, CP, 4D, DP, DC, DU, GP, HX, PC, SI, SM, TB, TC	AM, AT, BR, 4D, SI

AM = Amitrole; AT = Atrazine; BR = Bromacil; CS = Chlorsulfuron; CP = Clopyralid; 4D = 2,4-D; DP = Dalapon; DC = Dicamba; DU = Diuron; GP = Glyphosate; HX = Hexazinone; IP = Imazapyr; MF = Mefluidide; MM = Metsulfuron methyl; PC = Picloram; SI = Simazine; SM = Sulfometuron methyl; TB = Tebuthiuron; TC = Triclopyr; DE = Diesel; KE = Kerosene.

Amitrole - BLM has reexamined the risk assessment and examined additional data. BLM has determined that amitrole is no longer considered for proposed use in this document. Amitrole will be deleted in the Record of Decision.

Dalapon - Since drafting this document, producers are no longer manufacturing formulations registered for proposed use. Therefore, dalapon is no longer considered for use.

Note: High risks are defined as those exposures that may result in a margin of safety less than 100 or a cancer risk greater than 1-in-1 million.

Table 3-20

High Risks From Accidents From Herbicide Use on Rights-of-Way

Exposure Scenario	Systemic	Reproductive	Cancer
Skin Spill, Concentrate	All except DP, TB	All except DP, TB	AM, AT, BR, 4D, SI
Skin Spill, Mixture	All	All	AM, AT, BR, 4D, SI
Direct Spray, Person	AM, AT, BR, CP, 4D, DP, DC, DU, HX, SI, TB, TC, DE	AT, BR, 4D, DP, DC, DU, GP, SI, TB, TC	AT, SI
Drinking Directly Sprayed Water	AM, AT, 4D, DP, DU, SI, TC	AT, DU, SI, TB	AM, AT
Eating Fish From Directly Sprayed Water	AM, AT, BR, CP, 4D, DP, DU, HX, SI, TC	AM, AT, BR, 4D, DP, DC, DU, SI, TB, TC	AM, AT, SI
Immediate Reentry, Hiker	AT, DU	AT	—
Immediate Reentry, Picker	AM, AT, BR, CP, 4D, DP, DC, DU, GP, HX, MF, SI, SM, TB, TC, DE	AT, BR, CP, 4D, DP, DC, DU, GP, HX, SI, TB, TC	AT, SI
Eating Directly Sprayed Berries	AM, AT, BR, CP, 4D, DP, DU, HX, SI, TB, TC	AM, AT, BR, 4D, DP, DC, DU, SI, TB, TC	AM, AT, SI

Table 3-20 (Continued)

High Risks From Accidents From Herbicide Use on Rights-of-Way

Exposure Scenario	Systemic	Reproductive	Cancer
Drinking Water Contaminated by a Jettison of Mixture	AM, AT, BR, CP, 4D, DP, DC, DU, HX, PC, SI, SM, TB, TC, DE	AM, AT, BR, 4D, DP, DC, DU, GP, HX, SI, TB, TC	AM, AT, SI
Drinking Water Contaminated by a Truck Spill	All except IP	AM, AT, BR, CP, 4D, DP, DC, DU, GP, HX, PC, SI, SM, TB, TC	AM, AT, BR, 4D, SI

AM = Amitrole; AT = Atrazine; BR = Bromacil; CS = Chlorsulfuron; CP = Clopyralid; 4D = 2,4-D; DP = Dalapon; DC = Dicamba; DU = Diuron; GP = Glyphosate; HX = Hexazinone; IP = Imazapyr; MF = Mefluidide; MM = Metsulfuron methyl; PC = Picloram; SI = Simazine; SM = Sulfometuron methyl; TB = Tebuthiuron; TC = Triclopyr; DE = Diesel; KE = Kerosene.

Amitrole - BLM has reexamined the risk assessment and examined additional data. BLM has determined that amitrole is no longer considered for proposed use in this document. Amitrole will be deleted in the Record of Decision.

Dalapon - Since drafting this document, producers are no longer manufacturing formulations registered for proposed use. Therefore, dalapon is no longer considered for use.

Note: High risks are defined as those exposures that may result in a margin of safety less than 100 or a cancer risk greater than 1-in-1 million.

Table 3-21

High Risks From Accidents From Herbicide Use on Recreation and Cultural Sites

Exposure Scenario	Systemic	Reproductive	Cancer
Skin Spill, Concentrate	All except DP, TB	All except DP, TB	AT, 4D, SI
Skin Spill, Mixture	All	All	AT, 4D, SI
Immediate Reentry, Hiker	—	—	—
Immediate Reentry, Picker	AT, 4D, DP, DC, GP, HX, SI, TB, TC, DE	AT, 4D, DP, DC, GP, SI, TB, TC	SI
Eating Directly Sprayed Berries	AT, 4D, SI	AT, DC, SI, TB	—
Drinking Water Contaminated by a Truck Spill	All except IP	AT, 4D, DP, DC, GP, HX, PC, SI, TB, TC	AT, 4D, SI

AM = Amitrole; AT = Atrazine; BR = Bromacil; CS = Chlorsulfuron; CP = Clopyralid; 4D = 2,4-D; DP = Dalapon; DC = Dicamba; DU = Diuron; GP = Glyphosate; HX = Hexazinone; IP = Imazapyr; MF = Mefluidide; MM = Metsulfuron methyl; PC = Picloram; SI = Simazine; SM = Sulfometuron methyl; TB = Tebuthiuron; TC = Triclopyr; DE = Diesel; KE = Kerosene.

Amitrole - BLM has reexamined the risk assessment and examined additional data. BLM has determined that amitrole is no longer considered for proposed use in this document. Amitrole will be deleted in the Record of Decision.

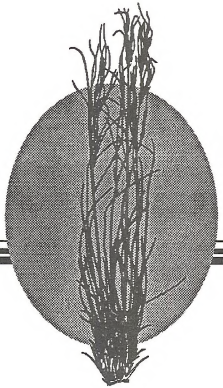
Dalapon - Since drafting this document, producers are no longer manufacturing formulations registered for proposed use. Therefore, dalapon is no longer considered for use.

Note: High risks are defined as those exposures that may result in a margin of safety less than 100 or a cancer risk greater than 1-in-1 million.

Chapter 3

Section 2

Impacts by Alternatives



SECTION 2

IMPACTS BY ALTERNATIVE

VEGETATION

The overall effect of all alternatives would be changes in vegetation composition, structure, or productivity in the areas treated. In some instances, certain species would be suppressed or removed as a result of treatment. Other species would increase, while others would remain essentially unchanged. In some instances, vegetation would be rejuvenated or resized. Species and structural diversity of a given site may be enhanced or reduced, depending on treatment objectives and kind of site. The results of treatment would include enhanced structure and diversity of wildlife habitat, increased productivity of herbaceous vegetation and browse, enhanced productivity of commercially valuable trees, suppression of noxious weeds, reduced fire and safety hazards, and maintenance of a community in a particular successional stage that best meets land use objectives for the site.

Herbicides would provide greater control of resprouting vegetation than other treatments, particularly when applied before burning. Manual methods would be used primarily to suppress target vegetation that does not resprout and in sensitive areas, such as riparian areas, where extreme control over application is necessary. Mechanical treatments would temporarily remove competing vegetation from sites and would often be reseeded following treatment, but would aid germination of grasses and hardwoods in forest situations.

Management after treatment is as important as treatment selection to ensure that treatment objectives are met in the long term. Post-treatment management is addressed in local land-use plans and activity plans, such as area of critical environmental concern plans, habitat management plans, allotment management plans, watershed plans, and coordinated resource management plans.

Under all alternatives, decisions pertaining to treatment locations and acreages are affected by and consider BLM past actions, actions of other agencies, and natural events such as wildfire occurrence, in order to avoid adverse cumulative impacts. A proposed treatment might be postponed or abandoned altogether if a wildfire occurred in or near the treatment area, making treatment either unnecessary or potentially impacting too much of the local area at one time. Treatments may be implemented in conjunction with other agencies to achieve common objectives across different land jurisdictions, or coordinated to avoid adverse cumulative effects of independent actions of different agencies. Coordination between BLM and other agencies for vegetation treatments and other agency actions is generally guided by various written agreements between local offices. Coordination requirements and cumulative effects are part of the site-specific environmental analysis documentation for every proposed treatment.

Riparian areas, including xeroriparian dry washes, will be avoided under all alternatives and site-specific treatments except where saltcedar control has been proposed. Standard operating procedures and mitigation are designed to minimize or eliminate impacts to riparian vegetation and are addressed in the site-specific environmental analysis for the proposed project. Therefore, except where specific treatments are designed to control or manage vegetation within riparian areas, there will be no significant adverse impacts to riparian zones in any analysis region under any alternative. For these reasons, riparian vegetation will not be discussed in detail.

The few treatments proposed within riparian areas are either for controlling noxious weeds or nonnative problem species such as saltcedar. All treatments are for small acreages and generally consist of manual applications of control measures to individuals, such as chainsawing saltcedar and painting the stump with herbicide. The techniques required to achieve effective control minimize the opportunity for undesired impacts.

The proposed acreage for biological treatments under all alternatives primarily targets introduced species that have been designated as noxious weeds. Biological treatments may occur in any analysis region in any portion of the EIS area. The use of biological treatments depends on the nature of the target species, dispersal of the weed, and availability of appropriate biological control agents. The objective of biological control methods is to bring weeds to an economic control level, not to eradicate them. Generally, a complex of agents is necessary to do this, and control is attained only over a period of several to many years. BLM is working with other Federal agencies and universities to identify and test potential biological agents for use on noxious weed species. Before an agent may be released, extensive testing must be done to ensure that potential agents are host-specific and will not be detrimental to economically important or endangered or threatened species, and that they do not carry parasites and dis-

eases. In addition, interaction between potential agents is examined, and the environments in which they operate most effectively are determined before release.

The sagebrush and plains grasslands analysis regions together contain nearly three-fourths of the acres proposed for treatment under each alternative, while the remaining analysis regions each constitute 10 percent or less of proposed treatment acreage. The greatest acreages of vegetation treatment are proposed under Alternative 1 (Table 1-1). Alternative 1 is the only alternative that allows a choice of the treatment method or program chemical that would be best suited to meet site-specific treatment objectives. Acreages proposed for treatment under Alternatives 2 and 4 are similar, but their impacts to vegetation would be quite different. Chemically treated acreage under Alternative 4 would be more than three times the chemically treated acreage under Alternative 2. Acreage treated by prescribed fire would be greatest under Alternative 3. Many noxious weeds would remain uncontrolled under Alternative 3. Alternative 5 proposes less acreage for treatment than any of the alternatives, as well as fewer acres of chemical treatment than any alternative except Alternative 3.

Alternative 1: Proposed Action

Under Alternative 1, all available treatment methods—manual, mechanical, biological, prescribed burning, and chemical—could be used. The sequence of treatments would be selected to take maximum advantage of the characteristics of the treatments, target species, and environmental considerations—to get desired results. The treatment selection would be determined by evaluating treatment objectives along with information on the physiological response of species in the target community to different treatment methods, the composition and productivity of vegetation in the target area, environmental considerations (proximity of human habitations and water bodies, endangered species, National Parks, and so on), and physical site characteristics (such as soil type, rockiness, and slope).

The proposed treatment area of 371,640 average annual acres per year comprises 0.23% (about one-quarter of one percent) of the total BLM lands within the EIS area (Table 2-1). Over the past 10 years, wildfires have burned an average of 529,610 BLM acres per year in the EIS area (BLM 1990). This is about 0.34% (about one-third of one percent) of the EIS area. Together, the average annual disturbance would amount to about 901,250 acres, or about 0.6% (six-tenths of one percent) of BLM lands within the EIS area. The extent of vegetative disturbance is not additive over the life of the EIS. Repeated wildfires occur in these same areas planned for treatment. When this occurs, acreage is reduced accordingly. The largest degree of cumulative impact under the Proposed Action is that vegetation will be managed and maintained under guidelines determined by local land use plans. Undesirable cumulative effects are possible but unlikely because of the scope and design of the Proposed Action. Areas to be treated are small in relation to the total EIS area and treatments will not be repeated during the life of the EIS.

Under Alternative 1, herbicides would be used to treat the largest number of acres, followed by prescribed burning, mechanical, biological, and manual methods. For all the vegetation analysis regions under this alternative, noxious weeds would be treated primarily by chemical and biological methods. Oil and gas production facilities, recreation areas, and rights-of-way would be treated by chemical and mechanical methods, with manual and biological methods used when appropriate. Rangeland areas would be treated predominantly by chemicals, prescribed burning, biological and some mechanical treatment.

Sagebrush

More than one-half of the acreage proposed for treatment under Alternative 1 would be in this analysis region. The primary treatment methods would be prescribed fire and chemicals. Prescribed fire would favor herbaceous vegetation over woody species in the short term, and treated areas would reflect this. Herbicides would be used on rangeland dominated by introduced annual grasses, such as cheatgrass and medusahead, followed by revegetation with perennial species. Chemicals also would be used to suppress shrubs in favor of herbaceous vegetation on some areas. The relative proportion of shrubs to herbaceous species left in treated areas would vary, depending on site management objectives. Chemical treatments that target woody species also may initially damage the herbaceous component, particularly forbs, but productivity would recover in the short term. Vegetation cover would initially be reduced following treatments but recover in the short term. Long-term impacts include a reduction in the extent of acreage dominated by annual grasses, increase in acres of perennial vegetation, and more sites with a shrub mosaic or predominantly herbaceous composition rather than closed stands dominated by shrubs.

Desert Shrub

Little treatment is proposed in this analysis region under Alternative 1. Small acreages of saltcedar would be controlled and converted to native, multi-species riparian vegetation. Short-term negative losses of cover would occur, but reestablishing

native vegetation would result in significant long-term benefits, particularly to the habitats of small birds, mammals, reptiles, and amphibians. Other treatments would be done with chemicals or by mechanical, manual, or biological methods to control noxious weeds and to reduce fire or other safety hazards on rights-of-way, recreation areas, and oil and gas production facilities.

Southwestern Shrubsteppe

This analysis region ranks just below pinyon-juniper in the number of acres proposed for treatment under Alternative 1. The primary treatment methods would be prescribed fire and chemicals. Prescribed fire favors herbaceous vegetation and sprouting woody species. Chemical treatments would most often suppress the sprouting woody species when they are in closed stands without sufficient fine fuel to carry a fire. Prescribed fire would control very young plants and maintain communities already dominated by herbaceous species, or it would follow a chemical treatment to burn standing dead woody material that inhibits movement and access to forage by animals. Chemical treatments that target woody species also might initially damage the herbaceous component, particularly broadleaf species, but productivity would recover in the short term.

Small acreages of saltcedar would be controlled and converted to native, multispecies riparian vegetation. Short-term negative losses of cover would occur, but reestablishing native vegetation would result in significant long-term benefits, particularly to the habitats of small birds, mammals, reptiles, and amphibians. The most significant impact of Alternative 1 in this analysis region would be to increase the proportion of herbaceous vegetation relative to woody vegetation. Grasses would be favored slightly over forbs in most chemically treated areas. Treatment would initially reduce total vegetative cover on the treated site, but it would recover in the short term. Long-term effects include increased acreage with a shrub mosaic or predominantly herbaceous composition rather than stands dominated by shrubs.

Chaparral-Mountain Shrub

Treatments proposed in this analysis region do not constitute a significant portion of the treatment program under Alternative 1. Prescribed fire, chemicals, and mechanical treatment would be used most often in interior chaparral communities. Prescribed fire alone would open and rejuvenate decadent stands of shrubs, increase the diversity and productivity of the herbaceous component, and reduce fuel loading and continuity. Chemical and mechanical treatments, in conjunction with fire, would be done if conversion from shrub-dominated to herbaceous communities was desired in local areas. Increased water yield also might result if the community is converted to grassland. Prescribed fire would be the most commonly used treatment method proposed in mountain shrub communities to resize and rejuvenate stands of Gambel oak and mountain mahogany for wildlife. The vegetation cover would initially be reduced after treatment but would recover in the short term. Long-term impacts would include the maintenance of a more open and vigorous shrub component and increased productivity of herbaceous species on some sites.

Pinyon-Juniper

This analysis region comprises slightly less than 10 percent of the acreage proposed for treatment under Alternative 1. Treatment methods would most frequently be mechanical and prescribed fire. Both of these methods favor herbaceous species over woody species. The long-term impact of Alternative 1 in this analysis region would be to increase the abundance and diversity of herbaceous vegetation and understory shrubs and to decrease tree cover. The relative proportion of trees to other species left in treated areas would vary, depending on site management objectives.

Plains Grassland

Approximately 20 percent of the acreage proposed for treatment under Alternative 1 is in this analysis region. Prescribed fire and chemical treatments would be used most often. The major impact would be an increase in herbaceous species, primarily grasses, and a decrease in the density and abundance of woody species. The vegetation cover would be reduced initially after treatment but recover in the short term. Long-term impacts would be maintenance of mostly open grassland communities.

Mountain/Plateau Grasslands

Treatments in this analysis region do not constitute a significant portion of the treatment program under Alternative 1. Proposed treatments would consist mainly of chemicals or prescribed fire to control noxious weeds or other herbaceous species or to suppress woody species. Some treatments might be started to control vegetation on rights-of-ways, oil and gas facilities, and recreation areas by chemical, mechanical, biological, or manual methods.

Coniferous/Deciduous Forests

This analysis region comprises the least acreage proposed for treatment under Alternative 1, mostly because BLM administers so little forested land. Forests would be managed primarily by combinations of chemical, mechanical, and prescribed fire methods. Most of the treatment acreage proposed for this analysis region is in important timber-producing areas. Significant impacts of Alternative 1 in this analysis region would include reduced fuel loads and reduced understory competition for timber species. Some treatments might be initiated to control vegetation on rights-of-ways, oil and gas facilities, and recreation areas by chemical, mechanical, biological, or manual methods.

Alternative 2: No Aerial Application of Herbicides

Under Alternative 2, aerial applications of herbicides (Figure 3-6) would not be permitted. The control of some target species in many areas would not be as effective as that under Alternative 1, and retreatment or maintenance treatments would have to be done more frequently. Exact combinations of manual, mechanical, bilogical, prescribed fire, and ground herbicide treatments (Figure 3-7) would be determined as was done for Alternative 1. Under Alternative 2, prescribed fire would be used on the greatest number of acres, followed by mechanical, bilological, chemical, and manual treatments (Table 1-1).

The 322,868 acre average annual treatment level proposed under Alternative 2 represents 0.20% of the total BLM lands within the EIS area (Table 2-1). Including wildfire occurrence as stated for the Proposed Action, average annual disturbance would be about 0.54% of BLM lands within the EIS area for this alternative. The extent of vegetative disturbance is not additive over the life of the EIS. Repeated wildfires occur in these same areas planned for treatment. When this occurs, acreage is reduced accordingly. Cumulative effects of Alternative 2 would be that vegetation management objectives of local land use plans would not be met within prescribed timeframes because managers would have fewer treatment methods available.

Under Alternative 2 for all the vegetation analysis regions, noxious weeds would be treated primarily by biological and chemical methods. Oil and gas

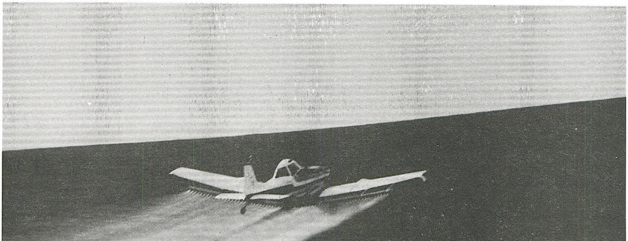


Figure 3-6. Aerial herbicide application.

Figure 3-7. Equipment for ground application of herbicides.

production facilities, recreation areas, and rights-of-way would be treated by chemical and mechanical methods, with manual and biological methods used when appropriate. Rangeland areas would be treated predominantly by prescribed burning. The impacts to riparian areas would be the same as those under Alternative 1.

Sagebrush

Under Alternative 2, prescribed fire and mechanical treatment would be substituted for aerial chemical application as much as possible when large acreages are proposed for treatment. More than one-half of the acres proposed for treatment under this alternative are in this analysis region, although total acreage treated would decrease relative to Alternative 1. Prescribed fire could not be substituted on sites without sufficient fine fuel to carry a fire, and mechanical treatment could not be substituted on sites where sprouting species such as rabbitbrush might be increased by such treatment. Alternative 2 would preclude chemical treatment of rangelands dominated by nonnative annual grasses. This could result in potentially significant negative cumulative effects to this analysis region by precluding reclamation of these areas and resulting in further losses of native sagebrush habitat through high frequency of wildfire.

The total vegetative cover would be decreased immediately after treatment but recover in the short term. In the long term, however, the treatment program under Alternative 2 would not be as effective as that under Alternative 1. More acres would continue to be dominated by annual grasses and monotypical stands of shrubs. The herbaceous component of communities would not be as diverse or productive as that under Alternative 1.

Desert Shrub

The effects of Alternative 2 in this analysis region would be the same as those under Alternative 1.

Southwestern Shrubsteppe

Under Alternative 2, prescribed fire would be substituted for aerial herbicide application as much as possible when large acreages are proposed for treatment. Prescribed fire cannot be substituted on sites

lacking sufficient fine fuel to carry a fire. Controlling sprouting, woody species in areas where an herbaceous community is sought could be difficult because herbicide use would be limited and sprouting may be enhanced by burning alone. Mechanical treatment could not be substituted for aerial chemical treatment on significant acreage, because non-plowing mechanical treatments would not prevent the resprouting and redominance of woody species and plowing treatments kill most perennial grasses and forbs that are unable to reproduce vegetatively. Total acreage treated in this analysis region would decrease relative to Alternative 1.

Under Alternative 2, the vegetative cover would be reduced immediately after treatment but recover in the short term. In the long term, however, this treatment program would not be as effective on upland communities as that under Alternative 1. More acres would continue to be dominated by shrubs, and the herbaceous component of communities would not be as diverse or productive as that under Alternative 1.

Chaparral-Mountain Shrub

The impacts of Alternative 2 in this analysis region would be similar to the impacts of Alternative 1. Total acreage treated also would be similar to Alternative 1. However, Alternative 2 would preclude the combination of aerially applied herbicides with prescribed fire in situations where a predominantly herbaceous community is desired to replace shrub communities.

Pinyon-Juniper

The impacts of Alternative 2 in this analysis region would be similar to the impacts of Alternative 1, because mechanical and prescribed fire treatments are most often used for vegetation treatments in this region. Acreage proposed for treatment also is similar to Alternative 1.

Plains Grasslands

Under Alternative 2, prescribed fire would be substituted for aerial chemical application as much as possible when large acreages are proposed for treatment. Acreage proposed for treatment under this alternative is less than in Alternative 1. Prescribed fire could not be substituted on sites lacking sufficient fine fuel to carry a fire. Mechanical treatment would not be substituted for aerial chemical treatment on significant acreage. Control of large infestations of noxious weeds or other broadleaf species would not be as effective under Alternative 2 as that under Alternative 1. The vegetative cover would be reduced immediately after treatment but recover in the short term. In the long term, however, the treatment program under Alternative 2 would not be as effective as that under Alternative 1 because more acres would continue to be dominated by shrubs. The herbaceous component of communities would not be as diverse or productive as that under Alternative 1.

Mountain-Plateau Grasslands

Under Alternative 2, treatments proposed to control noxious weeds and broadleaf species would not be as effective over large acreages as those under Alternative 1. However, total acreage proposed for treatment under this alternative is similar to Alternative 1. Ground application of chemicals, prescribed fire, or mechanical treatments would be substituted to the extent possible. The vegetative cover would be reduced immediately after treatment but recover in the short term. In the long term, however, the treatment program under Alternative 2 would not be as effective as that under Alternative 1.

Coniferous/Deciduous Forest

Alternative 2 would preclude much understory control in new commercial timber areas because prescribed fire or mechanical treatments are not satisfactory substitutes in that situation. Other impacts would be similar to Alternative 1. Total acreage proposed for treatment is similar to Alternative 1.

Alternative 3: No Use of Herbicides

The application of chemicals would not be permitted under Alternative 3. Control of some target species would not be possible in some areas because of lack of suitable substitute treatments. Vegetation treatment on oil and gas production facilities and rights-of-way would have to be replaced by manual or mechanical methods to the extent possible, or not done at all. The latter option would compromise the safety of oil and gas production facilities and create impossible maintenance problems on some rights-of-way. Recreation areas would be treated primarily by mechanical and manual methods.

The 285,650 acre average annual treatment level proposed under Alternative 3 represents 0.18% of total BLM lands within the EIS area (Table 2-1). Including wildfire occurrence as stated for Alternative 1, average annual disturbance would be about 0.52% of BLM lands within the EIS area for this alternative. Significant adverse long-term and cumulative effects could occur under this alternative in all analysis regions, including riparian areas, by further in-

vasion and increase of noxious weeds or undesirable nonnative species for which no biological control was available. These impacts would reach beyond BLM lands, as public lands would provide a source for infestation of adjacent private lands or lands managed by other agencies by uncontrolled weeds.

Exact combinations of manual, mechanical, biological, and prescribed burning treatments would otherwise be determined as for those under Alternative 1. The method of treatment on the largest number of acres would be prescribed fire, followed by mechanical, biological, and manual methods (Table 1-1).

Sagebrush

Under Alternative 3, prescribed fire and mechanical treatment would be substituted for chemical application as much as possible. More than one-half of the acreage proposed for treatment under this alternative would occur in this analysis region, but treated acres would be less than under the Proposed Action. Prescribed fire would have to be carefully controlled to avoid promoting invasion of undesirable annual species, and could not be substituted on sites lacking sufficient fine fuel to carry a fire. Mechanical treatment could not be substituted on sites where sprouting species such as rabbitbrush might be increased by such treatment. The total acreage treated in this analysis region would decrease relative to the Proposed Action. Alternative 3 would preclude chemical treatment of rangelands dominated by nonnative annual grasses. This could result in potentially significant negative cumulative effects to this analysis region by precluding reclamation of these areas and resulting in further losses of native sagebrush habitat through high frequency of wildfire.

The total vegetative cover would decrease immediately after treatment but recover in the short term. In the long term, however, the treatment program under Alternative 3 would not be as effective as that under Alternative 1. More acres would continue to be dominated by annual grasses and monotypical stands of shrubs. The herbaceous component of communities would not be as diverse or productive as that under Alternative 1.

Desert Shrub

The impacts of Alternative 3 in this analysis region would mostly be in riparian areas, on oil and gas facilities, and on rights-of-way. Attempts to control saltcedar in many riparian areas would not be successful, and reestablishment of native vegetation would be poor.

Southwestern Shrubsteppe

Under Alternative 3, prescribed fire would be substituted for chemical application as much as possible. However, the treated acres in this analysis region under this alternative would be fewer than under Alternative 1. Prescribed fire could not be substituted on sites without sufficient fine fuel to carry a fire. Mechanical treatment could not be substituted for aerial chemical treatment on significant acreage. The vegetative cover would be reduced immediately after treatment but recover in the short term. In the long term, however, the treatment program under Alternative 3 would not be as effective as under Alternative 1, because more acres would continue to be dominated by shrubs and the herbaceous component of communities would not be as diverse or productive. Attempts to control saltcedar in many riparian areas would not be successful, and reestablishment of native vegetation would be poor.

Chaparral-Mountain Shrub

The impacts of Alternative 3 in this analysis region would be similar to the impacts of Alternative 1, and treated acreage also would be similar. However, Alternative 3 would preclude the combination of aerially applied herbicides with prescribed fire in situations where a predominantly herbaceous community is desired to replace shrub communities.

Pinyon-Juniper

The impacts of Alternative 3 in this analysis region would be similar to the impacts of Alternative 1, because mechanical and prescribed fire treatments are most often used for vegetation treatments in this region. The total acres treated under this alternative would be only slightly fewer than those under Alternative 1.

Plains Grasslands

The acreage treated in this analysis region under Alternative 3 would be less than under any other alternative but still constitute nearly 20 percent of total acreage treated under this alternative. Prescribed fire would be substituted for chemical application as much as possible when large acreages are proposed for treatment. Prescribed fire could not always be substituted on sites without sufficient fine fuel to carry a fire or on sites inhabited by sprouting shrubs, such as honey mesquite, sand shinnery oak, or cholla. Mechanical treatment would not be substituted for aerial chemical treatment on significant acreage. The control of large infestations of noxious weeds or other broadleaf species would not be as

effective under Alternative 3 as that under Alternative 1.

The vegetative cover would be reduced immediately after treatment but recover in the short term. In the long term, however, the treatment program under Alternative 3 would not be as effective as that under Alternative 1. More acres would continue to be dominated by shrubs. The herbaceous component of communities would not be as diverse or productive as that under Alternative 1.

Mountain/Plateau Grasslands

Under Alternative 3, treatments proposed to control noxious weeds and broadleaf species would not be as effective over large acreages as those under Alternative 1. Prescribed fire or mechanical treatments would be substituted to the extent possible. The vegetative cover would be reduced immediately after treatment but recover in the short term. In the long term, however, the treatment program under Alternative 3 would not be as effective as that under Alternative 1.

Coniferous/Deciduous Forests

Alternative 3 would preclude much control of competing vegetation in commercial timber areas, and treated acreage in this analysis region under this alternative would be less than that under Alternative 1. Other impacts would be similar to Alternative 1, except for oil and gas facilities and rights-of-way.

Alternative 4: No Use of Prescribed Burning

Under Alternative 4, prescribed fire would not be permitted as a management tool to treat vegetation for any reason. The combinations of mechanical, manual, biological, and chemical treatments used would otherwise be determined as was done for Alternative 1. Chemicals would be used on more acres under Alternative 4 than under any other alternative, followed by mechanical, biological, and manual methods (Table 1-1). Noxious weeds would be controlled primarily by chemical and biological means; oil and gas production facilities, recreation areas, and rights-of-way would be treated by chemical, mechanical, biological, and manual methods.

The 318,470 acre average annual treatment level proposed under Alternative 4 represents 0.20% of total BLM lands within the EIS area (Table 2-1). Including wildfire occurrence as stated for Alternative 1, average annual disturbance would be about 0.54% of BLM lands within the EIS area for this alternative.

The extent of vegetative disturbance is not additive over the life of the EIS. Repeated wildfires occur in these same areas planned for treatment. When This occurs, acreage is reduced accordingly. A major cumulative effect of Alternative 4 would be that vegetation management objectives of local land use plans would not be met because prescribed fire, a valuable treatment method, is not available.

Sagebrush

Under Alternative 4, chemicals would probably be substituted for prescribed fire as often as possible, increasing chemically treated acreage to more than that under any other alternative. Effects on nontarget grasses and forbs would be greatest under this alternative, because chemicals commonly used to control woody species in this analysis region also may be detrimental to herbaceous vegetation, particularly forbs, depending on such factors as application rate and soil texture.

Vegetation production would be reduced in the short term after treatment but increase within a few years of treatment. The long-term impact of this alternative would be a decrease in woody species and an increase in herbaceous species. The relative proportion of shrubs to herbaceous species left in treated areas would vary, depending on site management objectives. Grasses would be favored slightly over forbs. Standing dead material left after treatment cannot be burned and would present a physical obstruction to browse and forage use in formerly dense stands.

Desert Shrub

The impacts of Alternative 4 in this analysis region would be the same as those for Alternative 1.

Southwestern Shrubsteppe

Chemical treatment would be substituted for prescribed fire under Alternative 4 as much as possible, but treated acreage would be less than that for Alternative 1. Whereas periodic burning can maintain root-sprouting shrubs at a mostly young age class in the community, chemical treatment would tend to kill more of them. Effects on nontarget grasses and forbs would be greatest under this alternative because chemicals commonly used to control woody species in this analysis region also may be detrimental to some herbaceous species, particularly forbs, depending on such factors as application rate and soil texture. Impacts to riparian areas would be the same as those under Alternative 1.

Vegetative production would be reduced in the short term after treatment but would increase within a few years of treatment. The long-term impact of this alternative would be a decrease in woody species and an increase in herbaceous species, but community diversity probably would not be as great as that under Alternative 1 because of the effects on nontarget species and the increased mortality of woody species from the increased use of chemicals. The relative proportion of shrubs to herbaceous species left in treated areas would vary, depending on site management objectives. Standing dead material left after treatment could not be burned and would present a physical obstruction to browse and forage use in formerly dense stands.

Chaparral-Mountain Shrub

The elimination of prescribed fire under Alternative 4 precludes use of an important tool used to treat vegetation in this analysis region. The available treatment methods are not satisfactory substitutes for fire when a vigorous shrub community is desired. The long-term impact of this alternative would be the aging of shrubs into thick, decadent stands that could die of old age and fuel buildup. The potential for catastrophic wildfire would increase significantly, in place of smaller areas burned under controlled conditions that would be less prone to such events.

Pinyon-Juniper

Under Alternative 4, most initial mechanical treatments of pinyon-juniper sites would be unaffected. It is common to follow mechanical treatment by burning to kill residual trees and to decrease obstruction from slash piles. This would be precluded under Alternative 4. In addition, no maintenance burning of herbaceous cover established after mechanical treatment would be allowed; therefore, the site would return more quickly to pinyon-juniper. The treated acreage under Alternative 4 would be less than that under Alternative 1. Chemicals would be substituted for fire to some extent, increasing the adverse effects on nontarget grasses and forbs. The substitution of certain chemicals also can increase the potential for post-treatment dominance by annual grasses on some sites. Slash piles remaining on the site contain nutrients that could contribute to site productivity, but the nutrients would only be released by burning. Old slash piles also would present a wildfire hazard. If slash piles were burned by wildfire under severely dry conditions rather than by prescribed fire under controlled conditions, damage could be done to the site because of high fire temperature.

Vegetative production would be reduced in the short term under this alternative but would increase within several years after treatment if revegetation is successful. The long-term impact of Alternative 4 in this analysis region would be to increase abundance and diversity of herbaceous vegetation and understory shrubs and to decrease tree cover. The relative proportion of trees to other species left in treated areas would vary, depending on site management objectives.

Plains Grasslands

Chemical treatment would be substituted for prescribed fire under Alternative 4 as much as possible. The treated acreage in this analysis region would be less than that under Alternative 1 but would comprise approximately one-fourth of the total acreage treated under Alternative 4. Whereas periodic burning would maintain root-sprouting shrubs at a mostly young age class in the community, chemical treatment would tend to kill more of them. The effects on nontarget grasses and forbs will be greatest under this alternative because chemicals commonly used to control woody species in this analysis region also may be detrimental to herbaceous vegetation, particularly forbs, depending on such factors as application rate and soil texture.

Vegetative production would be reduced in the short term after treatment but would increase within a few years of treatment. On some sites, community diversity would not be as great as that under Alternative 1 because of the effects on nontarget species and the increased mortality of target species from the increased use of chemicals.

Mountain/Plateau Grasslands

Chemicals are the primary treatment method in this analysis region, so treated acreage under Alternative 4 is similar to that under Alternative 1. This alternative would mostly affect treatments on mountain grassland sites to suppress woody species and would result in treatment being foregone if chemicals were not a satisfactory substitute.

Coniferous/Deciduous Forests

Eliminating prescribed fire under Alternative 4 would have serious consequences in this analysis region. Slash remaining from timber operations could not be burned, which would increase the potential for serious wildfire. The lack of understory burns in some forest types, especially ponderosa, allows the establishment of fuel ladders, also a serious wildfire hazard. Fire exclusion under this alternative would have a significant cumulative effect by favor-

ing conifers over aspen, resulting in a trend toward a long-term dying out of aspen stands. Chemical and mechanical treatments would still be done to manage species competing with conifers in commercial timber areas, but jeopardy of losing these resources to wildfire would increase.

Alternative 5: No Action (Continue Current Management)

Under Alternative 5, vegetation treatment would continue as currently being performed. The total acreage treated would be lower than that for any other alternative. Under Alternative 5, all available treatment methods—manual, mechanical, biological, prescribed burning, and chemical—could be used. However, the array of chemicals available for use would be less than that under Alternative 1. The chemically treated acreage under this alternative would be less than that under any other alternative. Exact combinations of manual, mechanical, biological, and prescribed burning treatments would otherwise be determined as was done for Alternative 1. Under Alternative 5, the method of treatment on the largest number of acres would be prescribed fire, followed by biological, mechanical, chemical, and manual methods.

The 242,505 acre average annual treatment level proposed under Alternative 5 represents 0.15% of total BLM lands within the EIS area (Table 2-1). Including wildfire occurrence as stated for Alternative 1, average annual disturbance would be about 0.49% of BLM lands within the EIS area for this alternative. The extent of vegetative disturbance is not additive over the life of the EIS. Repeated wildfires occur in these same areas planned for treatment. When this occurs, acreage is reduced accordingly. Major cumulative effects of Alternative 5 would be that noxious weed and undesirable plant treatment objectives throughout the vegetative regions would not be met.

Sagebrush

Under Alternative 5, approximately one-half of the acreage would be treated in this analysis region relative to Alternative 1. The acreage proposed for treatment under this alternative would nevertheless constitute approximately one-half of the total acreage treated under Alternative 5. The chemically treated acreage would be proportionally less under Alternative 5 than under Alternative 1. Short-term impacts to nontarget herbaceous species from chemical use, particularly forbs, would be decreased. There also would be a short-term loss of vegetative cover after treatment. Long-term impacts would be more acres dominated by shrubs or annual grasses and less community diversity relative to Alternative 1. The effects of treatment on oil and gas facilities, rights-of-way, and recreation areas would be similar to those under Alternative 1.

Desert Shrub

The effects on this analysis region under Alternative 5 would be similar to those under Alternative 1, except treated acreage will be slightly less. Acreage of riparian treatments in particular would be reduced under Alternative 5 relative to Alternative 1. In areas where herbicides are not available under this alternative, saltcedar control in riparian areas would not be expected to be very successful, and reestablishment of native vegetation would be poor.

Southwestern Shrubsteppe

The treated acreage would decrease by nearly one-half in this analysis region under Alternative 5 relative to Alternative 1. Treatment of riparian acres in particular would be reduced relative to Alternative 1. In areas where herbicides would not be available under this alternative, saltcedar control in riparian areas would not be expected to be very successful, and reestablishment of native vegetation would be poor. The chemically treated acreage would be proportionally less under Alternative 5 than that under Alternative 1. Short-term impacts to nontarget herbaceous species from chemical use, particularly forbs, would be decreased. There would be a short-term loss of vegetative cover after treatment. Long-term impacts would be more acres dominated by shrubs or annual grasses and less community diversity relative to Alternative 1. Impacts of treatment to oil and gas facilities, rights-of-way, and recreation areas would be similar to Alternative 1.

Chaparral-Mountain Shrub

Impacts to this analysis region under Alternative 5 would be similar to those under Alternative 1, except treated acreage would decrease significantly. The proportion of chemically treated acres would decrease relative to Alternative 1. Impacts of treatment to oil and gas facilities, rights-of-way, and recreation areas would be similar to Alternative 1.

Pinyon-Juniper

Impacts to this analysis region under Alternative 5 would be similar to those under Alternative 1, except not as many acres would be treated. Most treatments proposed in this analysis region would continue to be mechanical and prescribed fire.

Chemicals would continue to be used to control noxious weeds and treat oil and gas facilities and rights-of-way. Recreation areas would be treated with manual, mechanical, or chemical methods.

Plains Grasslands

The treated acreage in this analysis region would decrease under Alternative 5 relative to Alternative 1, but the proportion of chemically treated acres would remain approximately the same. Treatments proposed for this analysis region under Alternative 5 constitute approximately one-fourth of the total acreage that would be treated under this alternative. Impacts of Alternative 5 in this analysis region would be similar to impacts of Alternative 1.

Mountain/Plateau Grasslands

Impacts to this analysis region and acreage treated under Alternative 5 would be similar to those of Alternative 1.

Coniferous/Deciduous Forests

Impacts to this analysis region under Alternative 5 would be similar to those under Alternative 1, except not as many acres would be treated. The proportion of chemically treated acres would remain approximately the same relative to Alternative 1.

CLIMATE AND AIR QUALITY

Climate

Because the factors influencing climate are so large in scale compared with the size of any individual proposed vegetation treatment, none of the alternative methods would have any significant impact on climate.

Global carbon dioxide and methane levels are increasing, and have been called "greenhouse gases," implying their increased concentrations may lead to changes in precipitation and temperature (both in timing and intensity). All vegetation is important in the processing and recycling of oxygen and carbon through photosynthesis. By converting carbon dioxide into oxygen and plant fiber, carbon is "fixed;" removed from the atmosphere until the plant material either decomposes or burns. Alternatives 2 and 3 propose the greatest degree of prescribed burning, which would add carbon dioxide and fine particulate matter to the atmosphere.

Air Quality

The most significant impacts to air quality would be moderate increases in noise, dust, and combustion engine exhaust generated by manual and mechanical treatment methods; smoke from prescribed burning; and moderate noise and minimal chemical drift from the aerial application of herbicides. Impacts would be temporary, small in scale, and dispersed throughout the study area. These factors, combined with standard management practices (stipulations), minimize the significance of potential impacts. Federal, State, and local air quality regulations would not be violated. Potential cumulative impacts may occur when multiple prescribed fires occur simultaneously. In the Pacific Northwest (where cumulative impacts are most likely), smoke management committees limit burning by Federal, state and private groups to minimize cumulative impacts.

Alternative 1: Proposed Action

Under Alternative 1, more acres would be treated than under any other alternative, and all treatment methods could be used. Air quality impacts are not anticipated to change significantly from current conditions.

Alternative 2: No Aerial Application of Herbicides

Under Alternative 2, the aerial application of herbicides would not be allowed. Restricting the use of herbicides would increase smoke emissions for prescribed burning by nearly 50 percent, particularly in the sagebrush analysis region.

Alternative 3: No Use of Herbicides

Chemical treatment would not be used under Alternative 3, increasing the dependence on mechanical and prescribed burning methods and increasing smoke emissions by nearly 50 percent throughout the study area. Specifically, smoke emissions in the desert shrub, southwest shrubsteppe, plains grasslands, and mountain/plateau grasslands analysis regions would nearly double, with smaller increases in the sagebrush and pinyon-juniper analysis regions (50 and 20 percent, respectively).

Alternative 4: No Use of Prescribed Burning

Under Alternative 4, prescribed burning would not be used, increasing the dependence on chemical and mechanical treatment methods but causing only minor improvements in air quality. This is because risks of wildfires and resulting smoke impacts would increase. The conifer/deciduous forests analysis region currently has the greatest smoke impacts, where prescribed burning helps reduce available fuel under optimal smoke dispersion conditions.

Alternative 5: No Action (Continue Current Management)

Alternative 5 is the continuation of current vegetation treatment programs. The fewest number of acres would be treated, and chemical treatment would not be performed in some areas. Except in areas of urban and industrial development, the existing air quality is good throughout the study area. The greatest existing air quality impacts are because of prescribed fire smoke in the conifer/deciduous forests analysis region. Federal, State, and local air quality regulations are not violated.

GEOLOGY AND TOPOGRAPHY

None of the alternatives should significantly affect the geology or topography of the EIS area.

SOILS

Alternative 1: Proposed Action

Under the proposed alternative, more acres would be treated than under any other alternative, and all of the treatment methods could be used. Manual treatment methods generally do not directly disturb soils and are used mostly in small isolated areas because of their cost and labor intensiveness. They are not expected to have significant impacts when used under any of the alternatives.

Impacts from mechanical treatments could include runoff, wind and water erosion, compaction, and a reduction in nitrogen-fixing bacteria. These impacts are highly site- and treatment-specific but are most likely to occur on fine-textured soils lacking organic matter and soil structure with low aggregate stability and a tendency to form a crust.

The use of livestock as a biological treatment could result in surface erosion and compacted soil. However, these effects usually would not occur if a careful grazing plan were followed. The use of insects and pathogens has little potential for direct soil impacts. In general, the potential impacts of biological methods are negligible for all of the alternatives considered. Prescribed burning affects the soil's chemical properties, microorganism populations, physical properties, wettability, and erosion. The degree of impact depends on the severity of the burn, fuel type, soil type, soil moisture, weather patterns, topography, plant cover remaining, rate of negative recovery, and frequency and area of bare soil. Prescribed burning provides the positive effect of immediately releasing nutrients into the soil. Under the proposed alternative, prescribed burning would be the second most used treatment method.

Under the proposed alternative, the greatest proportion of program acreage would be treated with herbicides. Although the herbicides would not alter the soil's physical properties, soil microorganisms could be indirectly affected. Herbicides can either stimulate or inhibit soil microorganisms, depending on application rates and the soil environment. The potential adverse effects relate to possible toxic effects on soil microorganisms or changes in species composition of these organisms.

Alternative 2: No Aerial Application of Herbicides

Under Alternative 2, the impacts to soils may be greater than under Alternative 1. More acreage would be treated by prescribed burning and mechanical methods than under the proposed alternative. This could increase the likelihood of effects such as runoff, wind and water erosion, compaction, and reduced nitrogen-fixing bacteria, depending on the areas treated and the mechanical treatment used. The greatest impacts from burning could occur beneath piles of cut or chained pinyon, juniper, or conifer slash, if they were burned when dry enough to have a significant amount of fuel consumption. Such impacts would be localized, and in most cases, these sites would not be burned under extremely dry, heavy fuel conditions because of the risk of fire escape. Postfire erosion could occur if an extreme precipitation event occurred before revegetation in areas treated by either method.

Alternative 3: No Use of Herbicides

Alternative 3 has the potential to affect soils the most because more prescribed burning and mechanical treatments would be used than under the other alternatives. Therefore, the possibility of the impacts associated with these treatment methods occurring is greater than under the other alternatives. Because no herbicides would be used, the impacts associated with herbicide use would not apply.

Alternative 4: No Use of Prescribed Burning

Alternative 4 probably would affect soils the least because fewer acres would be treated mechanically than under Alternatives 2 and 3, and no acres would be treated by prescribed burning. However, when fire is not used to manage fuels, wildfire incidence could increase. Chemicals will be the most widely used treatment method, with more than half of the total acreage treated with them. The possibility of indirect effects on soil microorganisms could increase with so many more acres being treated.

Alternative 5: No Action (Continue Current Management)

The potential impacts of Alternative 5 are comparable to those under the proposed alternative, only slightly less. The same combination of treatment methods are available for both alternatives, but only fewer acres are treated under Alternative 5.

AQUATIC RESOURCES

Under all the alternatives, manual and biological treatment methods would have a negligible effect on aquatic resources. Mechanical and prescribed burning treatments (used in all but Alternative 4) would increase short-term erosion and sedimentation. Drift onto surface water may occur from herbicide treatments, (under Alternatives 1, 4, and 5), although mitigation measures make this unlikely. In general, because of the characteristics of the chemicals used, the properties of the soils in the EIS area, and the generally low rainfall in most areas, it is unlikely that herbicides would reach ground water.

The program flexibility under Alternative 1, with all treatment methods available for use, should allow for the best possible management of ground cover and thus the least erosion and sedimentation. Under Alternative 2, with aerial applications of herbicides not permitted, there is a reduced risk of contamination of surface waters from offsite drift. Alternative 3 could cause the greatest effects because it has the combined highest acreage of mechanical and prescribed burning treatments, but no herbicide drift would occur under this alternative because no herbicides are used. Alternative 4 should cause the least impacts because no prescribed burning would be used and relatively few acres would be treated by mechanical methods. However, more acres are treated by herbicides than under any other alternative, thus increasing the possibility of accidental surface water contamination. Alternative 5 should have effects similar to but somewhat lower than Alternative 1.

FISH AND WILDLIFE

In general, impacts to wildlife would be greatest where vegetation treatments are used most often. The potential for negative impacts is highest when large areas are treated. The greatest positive impacts are achieved when small, irregular shaped blocks are treated. Smaller treatment areas also would be most beneficial to maintaining or improving biological diversity. Proper project design and environmental analysis can ensure improved wildlife habitat and increased species diversity under all of the alternatives. Impacts on upland wildlife species can be beneficial or adverse for any treatment in any analysis region, depending on the individual project designs. All impacts will be analyzed assuming that the site-specific project design includes all necessary considerations for avoiding adverse effects and achieving beneficial impacts, and ensuring that biological diversity is not significantly affected.

In all of the analysis regions, aquatic and riparian habitats, including xeroriparian dry washes, are crucial to wildlife populations. These habitats would generally be avoided with all the alternatives, except the small acreages of hand treatment of saltcedar by stump cutting and brush painting with herbicides, a few acres of mowing saltcedar, and some spot treatment of noxious weeds. The only real adverse effects would be accidental; for example, because of escaped burns, herbicide spills, overland flow, erratic aerial drift, or poor contract supervision. The project design should consider the potential for these accidents and minimize their likelihood. If proper project design and mitigations are used, there will be no significant direct impacts to fish and other riparian wildlife species, which will benefit indirectly through improved watershed conditions and stabilization of stream channels and improved riparian vegetation as a result of upland vegetation treatments.

The risks to terrestrial and aquatic wildlife species from herbicides are greatest when the highest application rates are used, usually on utility rights-of-way and oil and gas sites. Risks are also increased when aerial application of herbicides occurs, especially by fixed wing aircraft, as the degree of control of where the herbicide is actually applied is decreased. Assuming similar degrees of risk to species, potential impacts to wildlife would be proportionate to the density of wildlife species using these areas or habitats. Herbicide treatments in habitats with high wildlife densities will have a greater direct negative impact from the herbicide than in the habitats with low wildlife densities. However, the potential beneficial impacts from vegetation treatments with herbicides are greatest in the habitats with the highest wildlife use.

The presence of threatened, endangered, or special status wildlife species in a proposed treatment area will require Section 7 (of the Endangered Species Act) consultation with the U.S. Fish and Wildlife Service.

Cumulative impacts are difficult to define on this scale without site-specific proposed treatments and a summary of previous treatments within an area being treated. The greatest potential for significant adverse impacts will be in areas with a history of large scale or a large number of past treatments. The sagebrush analysis regions of Oregon, Nevada, and Idaho are areas where extensive treatments have occurred and impacts to major species have been verified. Proposed treatments in these areas need to be well planned to prevent causing further adverse impacts to previously heavily impacted species (e.g. sage grouse). Site-specific analysis of all proposed treatments needs to evaluate the proposed actions as they relate to the surrounding wildlife habitats for all species impacted by the treatment and the effects on the total diversity of the wildlife populations and communities in the region. Treatments that are designed to result in major changes in vegetation communities and perhaps restore past vegetation communities will result in long-term changes in wildlife communities. These long-term changes must consider the overall impact and significance of eliminating and replacing these wildlife communities, especially if special status species are involved.

Since there are many data gaps in the understanding of the affects of specific land treatments on the multitude of wildlife species, it is very important to monitor the specific impacts of a particular treatment on the wildlife community being impacted. These monitoring studies should be accomplished in cooperation with the state wildlife management agency and the results made available to other interested agencies and personnel.

Alternative 1: Proposed Action

This alternative has the largest acreage for treatment and therefore the greatest potential impacts. The full range of treatment methods—manual, mechanical, biological, prescribed fire, and chemical—would be available. Therefore, the most efficient and environmentally acceptable method could be chosen to achieve the desired result. The maximum positive impact to wildlife habitat would occur under this alternative. This alternative also has the highest potential for adverse impacts. The largest acreage of current wildlife habitats would be disturbed under this alternative. Improper application of any of the proposed treatment methods could result in significant negative impacts to the wildlife communities. It is through application of proper mitigation in the site-specific project proposal and planning that adverse impacts are avoided. With proper planning most adverse impacts would be temporary and localized. The most significant long-term impacts would occur when permanent type-conversion treatments were applied. In these treatments significant long-term changes in the wildlife community would occur, perhaps total loss of some original wildlife species and addition of other new species moving in to replace them. This alternative will also result in the largest number of acres of existing habitat being disturbed. Aerial or ground application of 2,4-D, or diesel fuel as a carrier of herbicides, could have a significant adverse impact to bird eggs, and young of any wildlife species, if applied during these primary reproductive periods.

The largest acreage proposed for treatment is in the sagebrush analysis region, which has already received extensive vegetation treatment. Excessive sagebrush control has had a negative effect on sage grouse in many areas. Future treatments must avoid further impacts to sage grouse, especially in Oregon and Washington where they are being considered for listing as threatened or endangered. Treatment planning should avoid areas where extensive treatments have occurred in the past, unless a definite need is demonstrated. Sagebrush and pinyon-juniper treatments also can be detrimental to wintering big game in years when snow depth makes low plants unavailable and less desirable plants, such as sagebrush and juniper, are the maintenance diet. Climatic extremes and cumulative effects of past and other planned treatments must be considered in environmental analysis to avoid significant negative impacts.

Several vegetation treatments are proposed for recreating historical vegetation communities that have been lost or severely degraded through past land-use practices. These areas have evolved wildlife communities that are adapted to the current sit-

uation. The wildlife community in these areas may be quite different than the historic wildlife community. As a result of the proposed actions, which may be desirable from a biological diversity aspect, a significant displacement of wildlife may occur and some species may be eliminated. This would have a short-term negative impact; however, the long-term goal of improving damaged communities is worthy and overshadows the short-term negative impacts. Because the historic wildlife species may no longer exist in the immediate area, it may be necessary to reintroduce these extirpated species. The successful reestablishment of lost wildlife species into historical habitat, in good condition, is an extremely positive impact of this type of vegetation treatment.

The maximum control of noxious weeds would occur in this alternative, minimizing the potential for wildlife problems caused by these plants and preventing the loss of habitat through the encroachment of exotic, noxious vegetation on native ranges. This would have a beneficial effect on wildlife.

Some short-term negative impacts would occur to riparian species displaced by control of saltcedar by mowing and treatment of individual trees with herbicides; however, the long-term beneficial effects of restored native riparian species would be significant and offset any negative impacts.

This alternative contains a mix of all potential land treatments being considered for application. Therefore any impact, either adverse or beneficial, is possible in this alternative, complicating an analysis of cumulative impacts. Several treatments can occur in combination to achieve a desired end product, or treatments could occur in near proximity to each other. Potential effects of aerial and ground application of herbicide spraying could occur over the entire EIS area, in all types of habitats and conditions, complicating the mitigation techniques to be applied. To minimize impacts to fish and other aquatic wildlife, the use of certain chemicals will be minimized, and diesel oil carriers carefully regulated and applied when the treatment area is adjacent to aquatic habitats.

Alternative 2: No Aerial Application of Herbicides

This alternative allows the use of all treatment methods, but herbicide use is limited to ground applications. Some negative impacts may be expected from the use of less-effective methods as an alternative to the use of aerial application of herbicides. The most common alternative method is prescribed burning, which, if accomplished successfully, may be as beneficial as and have negative short-term impacts similar to the aerial application of herbicides, resulting in no major significant differences. Without the aerial application of herbicides, the potential of problem herbicide drift would be reduced, though not eliminated, with ground application. The control of noxious weeds would be less effective, and some negative impacts would occur to wildlife through direct effects and indirectly through increased competition with desired native forage plants. All other impacts are the same as in Alternative 1. Very few projects specifically designed to benefit wildlife would be foregone with this alternative, making this the most beneficial and least adverse alternative to the wildlife resource, while still retaining most of the treatment options. Again, as in Alternative 1, to minimize impacts to fish and other aquatic wildlife, the use of certain chemicals will be minimized, and diesel oil carriers carefully regulated and applied when the treatment area is adjacent to aquatic habitats.

Cumulative impacts will be more limited than Alternative 1 because there will be no potential for impacts from aerial spraying of herbicides, although all other methods will be available. Specific assessment of cumulative impacts will be accomplished at the site-specific environmental analysis level.

Alternative 3: No Use of Herbicides

Only manual, mechanical, biological, and prescribed burning treatments would be allowed under this alternative. Except for Alternative 5, this alternative has the least number of acres proposed for treatment. More than 60,000 acres proposed for herbicide treatment in Alternative 1 are proposed under other treatments in this alternative. Being substitutes, the alternative treatments may not be as effective as the original proposed treatments. Nearly 40,000 acres of these substitute treatment acres are for prescribed burning to replace herbicide spraying. Prescribed burning should be more cost effective than spraying and therefore more feasible. Whether prescribed burning would have more or less impacts than herbicides will depend upon the specific habitat and wildlife community being impacted. The most significant loss would be in the nearly 80,000 acres (annually) of potential habitat improvement not treated because of the lack of suitable substitute to herbicide treatments, including habitat type conversion areas without sufficient ground cover to carry prescribed fires. However, without specific site-specific proposals, the actual impact to wildlife is unknown. It is possible that only a few of the foregone treatments would have significant wildlife benefits.

Without the use of herbicides, the potential negative impacts caused directly by the herbicide chemical, carrier, or surfactant would not occur. This

would have a beneficial effect on wildlife, although it is not expected to be highly significant with proper mitigation. Without using herbicides, noxious weeds could not be as effectively controlled. In the long-term, the loss of wildlife habitat in some analysis regions could be significant, with a reduction in total habitat area and quality of habitat, and the related biological diversity. Another adverse impact is the loss of the only effective control method for saltcedar. Alternative 3 will have the greatest adverse impact on riparian area condition and management because of eliminating this ability to control saltcedar. This would effectively eliminate the ability to convert areas invaded by saltcedar to riparian areas of native vegetation and could have a significant long-term impact. In areas of currently seriously-degraded habitats, without sufficient vegetation to carry prescribed burns, the limitation on use of herbicides may also prevent recreation of historic native vegetation habitats and their associated wildlife communities.

The cumulative effect of long-term non-use of herbicides as a tool to manage problem vegetative species could be very significant. For many noxious weeds there is no suitable substitute for herbicide control. These species would continue to invade and spread their ranges without significant limitation. Also, there is no suitable substitute for herbicides for habitat type conversion in areas suffering from past abuses that cannot grow sufficient ground cover to carry fires. This alternative would cumulatively have a significant impact on our ability to effectively recover these areas of serious past abuse. This would be most serious in the sagebrush, pinyon-juniper, and southwestern shrubsteppe analysis regions. The spread of saltcedar would also not be significantly abated under this alternative.

Alternative 4: No Use of Prescribed Burning

As in Alternative 3, eliminating the use of prescribed fire would result in1use of substitute treatments. Almost half of the acreage proposed for burning in Alternative 1 would be proposed for treatment by a different method in this alternative, 34,000 acres would be sprayed with herbicide, resulting in the highest number of acres of herbicide spraying in any alternative. The most significant impacts from use of herbicides, as discussed in Alternative 1, will therefore occur in this alternative. For the other half, there would be no suitable substitute. This would result in the same types of impacts discussed for Alternative 3. The elimination of prescribed fire as a management tool also eliminates the most cost-effective method for large-scale type conversion on sites suitable for burning. These impacts also are the same as those discussed for Alternative 3. Another significant impact of eliminating burning as a tool is that prescribed burning often is used in conjunction with other methods to improve the final project. Fire frequently is used after herbicide treatment to remove the dead, standing woody materials, which often are impediments to wildlife movements. However, wildlife may use these materials for perches, cover, and nesting habitat, so their removal should be carefully considered and analyzed. The impact of removal can be either beneficial or detrimental. Selective removal, or leaving areas unburned, should be considered in the analysis. Fire also is used to clean up slash after chaining and other mechanical and manual treatments. This can be positive or negative, depending on the anticipated wildlife use of the area.

Prescribed fire would have definite short-term impacts on wildlife use of the area, especially immediately after the burn when cover and forage are temporarily extremely reduced. Some direct loss of wildlife, nests, and eggs also would occur. Depending on postburn climatic conditions, the return of high-quality forage (forbs and grasses) may be only a matter of days or weeks. The return of shrubs and trees is slower, as is the return of significant cover. In general, a well-planned prescribed burn is a significant long-term benefit to wildlife, especially when there is a dense cover of trees and undesirable shrubs preceding the burn. Habitat modification by prescribed fire is more beneficial to large mammals and birds than to smaller avian and mammalian species. Impacts from escaped fires that burn areas not proposed for burning, such as riparian areas, would be eliminated under this alternative, which could be significant in areas or situations where fire control is difficult. However, fires are not usually conducted under conditions that would make control difficult.

Other treatment impacts would be the same as for Alternative 1.

Cumulative impacts would be more significant in this alternative than all others. The potential for adverse impacts from aerial and other applications of herbicides would be highest of all alternatives. Most adverse impacts would be avoided through mitigation, but the potential risk from accidents would still be the highest. Since prescribed burning is the most cost effective treatment when it is appropriate, having to use alternative methods would raise the cost of treatment. The cumulative effect of this alternative would be quite significant, costing the Bureau an extra $1.5 million per year. Since the budget would not likely be raised to account for this extra cost, the end result would be a limitation in being able to effectively manage the habitat resources. Over the life of this EIS, this could significantly reduce the overall quality of wildlife habitats.

Alternative 5: No Action (Continue Current Management)

The impacts of continuing the existing situation would vary by State, depending on whether herbicide use is possible. Without using herbicides, there may be no effective way to achieve large-scale site conversion in areas with a history of abuse, as discussed under Alternatives 3 and 4. Without herbicide use, some States have no suitable means of effectively controlling noxious weeds, also discussed under Alternative 4. In all other situations, the impacts would generally be the same as for Alternative 1.

CULTURAL RESOURCES

The potential for damage to cultural resources varies among the alternatives depending on: (1) the amount and location of ground disturbance in manual and mechanical treatments; (2) the type of herbicide and application method used in chemical treatments; (3) the type of application method in biological treatments; and (4) the location, temperature, duration, and amount of ground disturbance in prescribed burning treatments.

The alternatives using mechanical methods to treat the greatest number of acres have the greatest potential for adverse impacts on cultural resources. Any adverse impacts of manual, prescribed burning, and chemical methods are likely to be lower than those from mechanical treatments.

Alternative 1: Proposed Action

Adverse impacts due to cultural resource damage are less likely under this alternative than under all of the other alternatives except Alternative 5. About 313,000 acres would be treated using manual, prescribed burning, and chemical methods; 58,000 acres would be treated mechanically.

Alternative 2: No Aerial Application of Herbicides

There is less potential for cultural resource damage under this alternative than under Alternative 3 but more than under Alternatives 1, 4, and 5. Approximately 252,000 acres would be treated using manual, prescribed burning, and chemical methods; 71,000 acres would be treated by mechanical methods.

Alternative 3: No Use of Herbicides

The potential for damage to cultural resources under this alternative is greater than under any of the others because more acres (74,000) would be treated using mechanical methods. A total of 285,000 acres would be treated using manual, mechanical, prescribed burning, and biological methods.

Alternative 4: No Use of Prescribed Burning

The potential for cultural resource damage under this alternative is less than under Alternatives 2 and 3 and more than under Alternatives 1 and 5. Approximately 249,000 acres would be treated using manual, biological, and chemical methods; mechanical methods would be used on 69,000 acres.

Alternative 5: No Action (Continue Current Management)

It is likely that less damage to cultural resources would occur under this alternative than under any of the other alternatives. A total of 242,000 acres would continue being treated using manual, prescribed burning, and chemical methods, which includes 42,000 acres that would be treated by mechanical methods.

RECREATION AND VISUAL RESOURCES

The goals of vegetation treatment on recreation areas include general maintenance, maintenance of the visual appearance of the areas, reduction of potential threats to the areas, plants and wildlife, protection of visitors' health and welfare by controlling noxious weeds and poisonous plants, and fire control. In the program areas that are easily visible where the appearance of the area is important (for example, recreation areas and public domain forests), treatments would be made that cause the least adverse visual impact. Some short-term scenic degradation would be associated with each of the program alternatives.

Alternative 1: Proposed Action

The proposed alternative allows the best combination of treatment methods for a specific site to be implemented. Manual and mechanical treatment methods are the most widely used techniques in recreation areas, but in some instances, using herbicides is preferable. For example, the preferred treatment for poison oak and other undesirable sprouters is herbicide application, because these weeds are difficult to eliminate otherwise. There may be short-term adverse impacts under Alternative 1, especially in areas where prescribed burning and herbicides are used. Some areas might be temporarily unusable after herbicide applications, and edible fruit and berrypicking opportunities may be lost. Because of smoke and blackened areas from prescribed burns, visitors may spend less time at a particular site. However, the long-term impacts would be beneficial. The risk of visitor exposure to undesirable plant species would be decreased and habitat for desirable plants and wildlife would improve; therefore, recreation hours spent at a particular site would be expected to increase.

Under Alternative 1, the principal area treated would be rangeland, and most treatments would be herbicide applications and prescribed burning. Adverse visual impacts could include a reduced variety of vegetation in chemically treated areas, blackened areas from burns, and visibility impairments from smoke. However, these adverse impacts would be temporary, particularly the visual effects of smoke, and there could be long-term beneficial impacts because regrowth of more aesthetically desirable plants would be possible. Some mechanical treatments would be used under the proposed alternative. These would occur on rangelands and in forests. The adverse visual impacts could include unsightly exposed soil or disrupted land surfaces. However, these impacts would be short term, and the potential long-term impacts would include the regrowth of more visually pleasing annuals, perennials, and shrubs. Manual treatment methods, which are virtually the same under all the alternatives, would have a low visual impact because, in general, they are implemented in areas that are difficult to reach by vehicle (and that are not readily visible to a large number of people, or in areas that are sensitive, so care would be taken to avoid disrupting the area to a great extent. The level of use of biological treatment methods is expected to remain the same under all of the alternatives. Biological treatment would be used in areas where livestock is a common sight, so the visual impacts would be minimal.

Alternative 2: No Aerial Application of Herbicides

Alternative 2 should have the same impacts as the proposed alternative in recreation areas because herbicides are not applied aerially in these areas and the same treatment methods could be expected to be used. Dispersed recreation activities could be affected because more area would be treated with prescribed burns. Hunting, camping, backpacking, and horseback riding would probably shift to unburned areas. In the long term, the prescribed burning would make the areas more attractive for these activities by improving the habitat for various flora and fauna.

Under this alternative, the principal treatment methods used would be mechanical treatments and prescribed burning. The increase in the use of mechanical methods, such as chaining and tilling, would result in a greater visual contrast between treated and untreated areas (for example, broken trees, disrupted land, and exposed soil). More areas would be burned under Alternative 2; therefore, there would be more blackened areas and more smoke than under Alternative 1. Manual treatment methods would be much the same as under Alternative 1, and the impacts would also be the same. Manual methods would be used in sensitive areas, so care would be taken to avoid disturbing the area to a great extent; or they would be used in areas difficult to reach by vehicle and would therefore not be highly visible. Biological treatments would remain the same as in Alternative 1.

Alternative 3: No Use of Herbicides

No use of herbicides in recreation areas would have detrimental effects. Compared to the proposed alternative, approximately 20 percent less area would be treated for the control of noxious weeds and poisonous plants. Visitor use in these areas could decline to avoid exposure to the uncontrolled undesirable plants. Manual and mechanical treatment methods have been the preferred techniques in the past, but in some cases (for example, undesirable sprouting species), these methods may not be effective. If nonchemical measures fail to control undesirable species in the areas that are treated, visitor use may also decline. The use of prescribed burning would be expected to increase under this alternative, possibly resulting in decreased air quality from smoke, as well as more blackened areas that would be avoided by recreationists.

If no herbicides are used, most acreage would be treated with prescribed burns, and more mechanical treatments will be used than under any other alternative. Fewer acres in more highly visible areas, such as recreation areas and rights-of-way, would be treated altogether. These differences have the adverse effects of increasing the number of blackened areas readily visible, the number of vehicles disrupting the areas, and the amount of undesirable vegetation crowding out visually pleasing vegetation. The amount of biological treatments would not increase, and they still would be conducted in areas where grazing is expected, so the visual impacts would be negligible. Under Alternative 3, the contrasting brown areas that herbicide use causes would not develop, but in the long term, visually desirable vegetation might be displaced by visually undesirable plants.

Alternative 4: No Use of Prescribed Burning

Alternative 4 could have both adverse and beneficial impacts. Manual treatment methods under this alternative are not expected to have adverse impacts because these treatments are species selective and are done in sensitive areas with as little disturbance to the environment as possible. The use of mechanical methods could increase; therefore, more exposed soil and disrupted land could be expected. Herbicide applications could be expected to increase under this alternative; therefore, recreational opportunities could be adversely affected because of temporary site closures, wildlife habitat changes, and the loss of edible fruit and berrypicking opportunities (USDA 1988). Habitat improvement opportunities are highest in alternatives that use prescribed fire. These opportunities decrease as the use of fire is restricted (USDA 1988).

Under this alternative, fewer acres would be treated than under the proposed alternative. Most of these acres would be on rangeland and public domain forests. More area would be treated with herbicides than in the other alternatives, which could result in more contrasting brown areas and a decreased variety of vegetation on treated sites. Manual and mechanical methods would be virtually the same as under the proposed alternative; therefore, their visual impacts are expected to be the same. With no prescribed burning, there would be no blackened areas and no problems with smoke inhibiting vision.

Alternative 5: No Action (Continue Current Management)

Under Alternative 5, fewer total acres would be treated than under the other alternatives. Recreation sites are likely to be treated the same as in the proposed alternative because the goal is the same. Of the alternatives that include prescribed burning, this alternative would have the least effect on dispersed recreation because fewer acres are treated with burns.

Locally, the visual impacts of the treatment methods under Alternative 5 would be the same as under Alternative 1, but overall, the impacts would not be as great because fewer acres are treated. The principal difference in these alternatives is the number of acres treated with herbicides. Under Alternative 5, the area treated chemically is relatively small; therefore, the impacts, both adverse and desirable, would be lower than under Alternative 1.

LIVESTOCK

Alternative 1: Proposed Action

Alternative 1 could yield the highest positive impact by providing the largest increase in desirable forage for livestock. Application of herbicides is the most effective and efficient way of controlling competing vegetation and some noxious weeds. However, aerial herbicide application also could kill some shrubs and trees that are used for shelter by livestock. Based on the nontarget species risk assessment, livestock are not expected to be directly affected by any of the proposed herbicides. The number of plants toxic to livestock, such as leafy spurge and knapweed, would be reduced. The use of prescribed burning in some areas could reduce competing vegetation and encourage thicker regrowth of desirable livestock forage plants.

Alternative 2: No Aerial Application of Herbicides

Under Alternative 2, less forage would be produced than under the proposed alternative because, without the use of aerially applied herbicides, it would be more difficult to control some species of

competing vegetation. More acres would be treated with mechanical methods, but these methods are not always effective in encouraging growth of desirable plants. Fewer total rangeland acres would be treated under the second alternative than under the proposed alternative; therefore, infestations of competing vegetation and noxious weeds would be more prevalent.

Alternative 3: No Use of Herbicides

Under Alternative 3, fewer acres would be treated than under Alternatives 1 or 2. There would be a decline in desirable forage because undesirable species would not be controlled on a greater portion of rangeland than under Alternatives 1 or 2. Livestock could be exposed to more toxic weeds than under the first two alternatives. There would be an increase in prescribed burns, which would have positive impacts on some rangeland sites by increasing desirable forage.

Alternative 4: No Use of Prescribed Burning

Under Alternative 4, herbicide application would be the principal treatment method used. Manual and mechanical methods would be similar to those used under the proposed alternative. They are sometimes inefficient and ineffective in controlling unwanted vegetation. With the increase in herbicide use, livestock could be more readily exposed. To avoid livestock exposure, more rangeland would have to be made temporarily unavailable for grazing. On brushy sites, herbicide use could result in increased productivity by killing competing vegetation. However, without the use of prescribed burning, woody material serving as physical obstructions to livestock use of some areas would remain.

Alternative 5: No Action (Continue Current Management)

The principal difference between this and the other alternatives, except Alternative 3, with respect to livestock is that fewer acres would be treated with herbicides under Alternative 5. In some areas, use of herbicides would not be allowed because of current restrictions. Livestock may be adversely affected by having less palatable forage if undesirable plants are not controlled effectively with the other treatment methods. Livestock also would be more likely to be exposed to those toxic weeds most effectively controlled by herbicides.

WILD HORSES AND BURROS

Alternative 1: Proposed Action

The use of all methods of vegetation treatment should improve habitat areas, thus benefiting wild horse and burro populations. This alternative should not pose any short-term or long-term threats to these animals' habitat, but the impacts must be addressed on a site-specific basis. Alternative 1 would yield the highest positive impact by providing the largest increase in desirable forage for wild horses and burros. Based on the nontarget species risk assessment, herbicides should not significantly affect horse and burro populations under any of the alternatives that use herbicides. Although adverse impacts to habitat areas would be temporary and localized, the aerial application of herbicides could kill some shrubs and trees that wild horses and burros use for shelter.

Alternative 2: No Aerial Application of Herbicides

This alternative allows for the use of all five vegetation treatment methods, except chemical treatment would be restricted to ground-based techniques. The use of all methods of vegetation treatment should improve habitat areas, thus benefitting all herd populations. Although the sequence of treatments would be selected to take maximum advantage of the available methods, the control of some target species would not be as effective as Alternative 1. Exact combinations of manual, mechanical, biological, prescribed burning, and chemical treatments would be determined by examining information such as type of undesirable species, composition of understory, composition of canopy, and soil characteristics. In some instances, chemical treatment would be replaced by prescribed fire. The overall effect of Alternative 2 would be less forage production and less control of noxious weeds.

Alternative 3: No Use of Herbicides

Only four of the five vegetation control methods —manual, mechanical, biological, and prescribed burning—would be used with this alternative. Because nonchemical methods would be employed, the potential exists for the remaining treatments to fail to control vegetation. Target species would compete with and reduce desirable forage species, which could adversely affect herd populations. Wild horses and burros potentially could be harmed if toxic vegetation species are not controlled using these methods.

Alternative 4: No Use of Prescribed Burning

This alternative allows for the use of only four vegetation control methods—manual, mechanical, biological, and chemical. Because prescribed burning would not be used to control target vegetation, many habitat areas will exhibit only mature seral stages, thus decreasing the desirable habitat and biodiversity of the area. However, over the long term, the available treatment methods could improve some habitat areas, thus increasing the abundance of forage in the area, which would be advantageous for herd populations.

Alternative 5: No Action (Continue Current Management)

Fewer total acres would be treated under this alternative. The result would be less available forage for wild horses and burros than under other alternatives. These animals also could be affected directly from the ingestion of poisonous noxious weeds not treated under Alternative 5.

SPECIAL STATUS SPECIES

Probability of adverse impacts to special status plant and animal species from all alternatives is low. Each proposed project is screened for its potential impacts to special status plants and animals during the Environmental Assessment process. Known ranges and habitat preferences of special status species are compared to the proposed project area through information maintained by BLM, through contact with other Federal or State agencies, or through contact with other knowledgeable individuals. Site-specific investigations are conducted when there is likelihood that a special status species may be present in the proposed project area. Potential impacts of the proposed project are determined from the site-specific investigations along with information obtained from other agencies. As a result of field investigations and coordination with knowledgeable individuals, project design or size may be adjusted, the project may be deferred to another time of year, off-site mitigation may be recommended, other stipulations may be applied while the project is being carried out, or the project may be abandoned altogether, based on the nature of potential impacts. No action will be taken under any alternative that would adversely affect the recovery of any threatened or endangered species.

WILDERNESS AND SPECIAL AREAS

Alternative 1: Proposed Action

Under Alternative 1, all available treatment methods could be used. Whether these methods would be used in a particular wilderness area would be addressed in a site-specific environmental assessment. With the restrictions already placed on vegetation treatment in special areas, Alternative 1 would allow the most treatment choices.

Alternative 2: No Aerial Application of Herbicides

Under Alternative 2, aerial application of herbicides would not be allowed. This would decrease any possible adverse effects on sensitive zones located in special areas, such as habitats of aquatic and special status species. However, the removal of particularly widespread target species would be reduced, possibly resulting in increased competition with native species.

Alternative 3: No Use of Herbicides

Chemical treatment would not be used under Alternative 3. This would increase the dependence on mechanical and prescribed burning methods, which could cause adverse impacts, especially visual, in some areas. Nevertheless, the use of no chemical treatment would prevent some possible adverse effects on fish and wildlife species.

Alternative 4: No Use of Prescribed Burning

Under Alternative 4, prescribed burning would not be used. This would increase the dependence on chemical and mechanical treatment methods, which could be detrimental in some areas. Under this alternative, prescribed burning would not be used to correct the fire exclusion problem that exists in some regions. Risks of wildfires could increase under this alternative.

Alternative 5: No Action (Continue Current Management)

Alternative 5 is the continuation of current vegetation treatment programs: fewer acres are treated and no chemical treatment is allowed in some areas. The decrease in acres treated may reduce the wilderness and special areas acres included in the program, thus decreasing potential adverse impacts.

HUMAN HEALTH AND SAFETY

Alternative 1: Proposed Action

Under the proposed alternative, manual methods of vegetation treatment should not affect members of the public; however, workers are likely to be affected by minor injuries from the use of hand tools or major injuries from the use of power tools. Mechanical methods should not affect the public, although there is a slight risk of injury from flying debris near mowing operations on highway rights-of-way projects. Workers would be at risk of injuries when they use tractors and other heavy equipment. Neither workers nor members of the public should be affected by any biological vegetation treatment methods.

Sensitive members of the public and some workers may experience minor ill effects, including eye and lung irritation from the smoke of prescribed fires. Workers may suffer burns from igniting or managing prescribed fires, although normal safety precautions should minimize this possibility. Escaped fires may place workers or members of the public at risk, but again, safety precautions in normal fire management practice should minimize the possibility of escapes and limit any risk to human health should wildfires occur.

Amitrole may affect members of the public exposed to it after herbicide treatment of rangeland, public-domain forests, or rights-of-way. None of the other herbicides should affect members of the public in routine applications, although they may be affected if they are exposed as a result of an accidental spraying or spill. Workers may experience health effects in routine applications of a number of the proposed herbicides, particularly in aerial applications to rangeland, oil and gas sites, or rights-of-way. Human health would benefit from treatment of noxious weeds and poisonous plants that adversely affect humans.

Alternative 2: No Aerial Application of Herbicides

Under this alternative, there would be somewhat increased risks, as compared to Alternative 1, of injury to workers from mechanical treatments and prescribed fire because of the increased acreage for those methods. Sensitive members of the public would be at higher risk of minor effects from smoke. The risks of public and worker health effects from herbicides would be reduced. More untreated acreage than under Alternative 1 increases the possibility of adverse effects from noxious weeds and poisonous plants.

Alternative 3: No Use of Herbicides

Under this alternative, the risk, as compared to Alternatives 1 and 2, of injuries to workers from manual and mechanical treatments and prescribed fire would increase slightly. Sensitive members of the public would be at higher risk of minor effects from smoke. Risks of public and worker health effects from herbicides would be eliminated. There would be less control of weeds that are hazardous to human health than in Alternatives 1, 2, and 4.

Alternative 4: No Use of Prescribed Burning

Risks to workers of injury from fire and to workers and the public of effects from smoke would be eliminated under this alternative. Risks of worker injuries from mechanical methods and hand tools would be about the same as those for Alternatives 1 and 2. Risks of health effects from the use of herbicides would be the highest of any of the alternatives because more than half the program acreage would be chemically treated.

Alternative 5: No Action (Continue Current Management)

This alternative would present risks of the same types of human health effects as described for Alternative 1, but a somewhat lower potential incidence of effects is likely, because the acreages treated by all methods are lower in every case.

SOCIAL AND ECONOMIC RESOURCES

Social Resources

Many of the social effects of vegetation treatment programs occur as a result of changes in jobs or personal income. Compared with total employment or personal income, employment or income changes resulting from the implementation of vegetation treatment may seem small. However, these changes may be important when considered on a local or site-specific basis to individuals who rely on the continued productivity of public lands and employment in vegetation treatment activities for their livelihood.

BLM's vegetation treatment program alternatives would directly and indirectly affect social conditions and attitudes. Direct impacts would occur if an individual's sense of well-being or economic security were affected by BLM's decision on the use or restriction of particular vegetation treatment methods. Indirect effects would occur as a result of economic outcomes of BLM policies and in response to gains or losses of recreational opportunities or access to subsistence activities. For example, reactions to changes in the availability of jobs and dependence on certain jobs are social effects derived from economic impacts. All of these impacts, direct and indirect, could affect lifestyles and community stability.

Vegetation treatment can be controversial, as demonstrated by the range of comments received during the scoping period (see Appendix B). For example, smoke from prescribed burning is likely to cause some public concern about air quality, and chemical treatment raises concerns about human health and safety. There would be some unsettling social effects no matter which program alternative is chosen because the affected population is not homogeneous. Opposition could be most intense in areas closest to treatment, but also would occur in more distant areas. Wherever these issues arise, they should be considered in the project-level design and site-specific environmental analyses. Appropriate public participation and other information efforts would likely mitigate these potential negative social effects.

Economic Resources

The Western States depend on the agriculture and forestry industries for employment and revenues from the sale of related goods and services (see Chapter 2, "Economic and Social Resources"). The direct economic impacts of all of the vegetation treatment program alternatives include increases in both employment and sales of treatment materials. The subsequent increase in personal incomes and revenues would benefit the economies of the Western States if the employees and equipment needed are acquired within these States.

Vegetation Treatment Costs

Total annual treatment costs were estimated for each program alternative to provide a quantitative basis for comparing the alternatives. Total costs for each alternative were calculated by multiplying the acreage treated by each method by treatment costs per acre. The per acre treatment costs were based on those used in previous vegetation treatment EISs (BLM 1985a, BLM 1987g, USDA 1988). The costs estimated (Table 3-22) include expenditures for chemicals, labor, equipment, and administration of the treatment. Different projects within the same treatment category have variable costs depending on the characteristics of each project.

Estimated program costs range from $15.9 million annually for Alternative 4, No Prescribed Burning, to $9.3 million for Alternative 5, No Action (Continue Current Management). The number of acres treated in each program differ, however, so a comparison of these total costs does not indicate the relative magnitude of per acre treatment costs. Alternatives 1 and 5 are the least expensive at $39 and $38 per acre, respectively; Alternative 4 is the most costly at $50 per acre.

Direct Economic Impacts

Employment Opportunities

The number of jobs that could be available under each program alternative depends on both the labor intensity of the treatment methods used and the number of acres treated. Manual treatment is the most labor intensive and chemical, the least:

Treatment Method	Percent Labor
Manual	92
Mechanical	39
Biological	*
Prescribed Fire	58
Chemical	
Aerial	17
Ground	26

* Biological data are not available; grazing management represents a small component of BLM labor.

Source: USDA 1988.

Table 3-22

Annual Vegetation Treatment Costs by Program Alternative

Treatment Method	Cost/Acre[1]	Alternative 1: Proposed Action		Alternative 2: No Aerial Application of Herbicides		Alternative 3: No Use of Herbicides		Alternative 4: No Prescribed Burning		Alternative 5: No Action	
		Acres	Cost	Acres	Cost	Acres	Cost	Acres	Cost	Acres	Cost
Manual	$235	14,070	3,306,450	14,470	3,329,950	13,870	3,259,450	13,670	3,212,450	12,770	3,000,950
Mechanical	100	58,115	5,811,500	71,165	7,116,500	74,215	7,421,500	69,165	6,916,500	41,945	4,194,500
Biological	—[2]	60,175	—	60,075	—	60,175	—	60,175	—	57,635	—
Prescribed Burning	10	97,765	977,650	132,290	1,322,900	137,390	1,373,900	0	0	92,680	926,800
Chemical											
Aerial:											
Helicopter	30	55,975	1,679,250	0	0	0	0	94,740	2,842,200	1,395	41,850
Fixed-Wing	15	58,700	880,500	0	0	0	0	46,000	690,000	24,370	365,550
Ground:											
Vehicle	50	21,045	1,052,250	38,033	1,901,650	0	0	28,075	1,403,750	9,615	480,750
Hand	130	5,795	753,350	7,135	927,550	0	0	6,645	863,850	2,095	272,350
Total		**371,640**	**14,460,950**	**322,868**	**14,598,550**	**285,650**	**12,054,850**	**318,470**	**15,928,750**	**242,505**	**9,282,750**
Cost per Acre			**38.91**		**45.22**		**42.20**		**50.02**		**38.28**

[1] Costs are in 1987 dollars.

[2] Biological treatment costs vary considerably; therefore, average costs are not available. However, costs for biological treatment in the State of Oregon for 1988 ran approximately $2.75 per acre for grazing treatment on 34,500 total acres; total cost was $95,000.

The increase in employment that would be required to implement Alternatives 1 through 4 is not likely to be significant because current BLM staff levels are adequate to treat the additional acreage with occasional summer employees.

Regional and local employment benefits would be greatest if any new jobs were filled by western residents. Alternatives 2 (No Aerial Application of Herbicides) and 3 (No Use of Herbicides) could provide the most job opportunities because the largest acreages are treated using manual and prescribed burning, the two most labor intensive methods. Alternative 4 (No Use of Prescribed Burning) could provide the least potential for new jobs. Implementation of Alternative 1 (Proposed Action) could provide more employment opportunities than Alternative 4. Under Alternative 5, No Action (Continue Current Management), no new jobs would be created.

Sales of Treatment Materials

Materials needed for vegetation treatment include fuel for vehicles and equipment, ignition materials for prescribed burning, and herbicides. Revenues from the sale of these items would depend on the quantities purchased, which in turn depend on several factors: the fuel efficiency of the vehicles or equipment used (as described in Energy Requirements), the type of ignition materials necessary, and the herbicide formulation. The cost of herbicides proposed for use in this vegetation treatment program, for example, ranges from $8 (2,4-D amine) to $130 (Arsenal) per gallon (University of Wyoming 1988). Furthermore, as previously mentioned, local economies would benefit only if these materials were made by or purchased from western suppliers. The effect of the sale of these treatment materials on the local economies therefore cannot be estimated for each program alternative.

Indirect Economic Impacts

Indirect economic impacts occur as a result of other actions. They are generally difficult to quantify, and the incidence of the cost of these impacts is not always clear. For example, insufficient management of rights-of-way could cause damage to electric transmission lines or railways; the owners must pay for repairs or maintenance, but these additional costs may be passed on to consumers and shareholders. Poor range management may result in the death of livestock and wildlife because of ingestion of noxious weeds and poisonous plants. Or, if public domain forests, cultural resources, and recreation sites are not maintained, visitors' enjoyment of these sites could decline, representing lost value to these visitors, and fewer people may visit in the future. If an admission fee is charged, this would result in less revenues from the site.

The largest number of acres would be treated under Alternative 1 (Proposed Action); thus, indirect costs would probably be lower than under the other four alternatives. The elimination of treatment methods or application methods in the other program alternatives causes the total number of acres treated to decline. Thus, vegetation that could optimally be treated by one method may not be treated or may be treated by an alternate method. As acreage goes untreated, or if alternate means of treatment are not effective, indirect costs are likely to rise.

UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

Implementation of any alternative would result in some adverse environmental impacts that cannot be avoided. Standards and guidelines, from BLM manuals—and mitigation developed in this Final EIS—are intended to keep the extent and duration of these effects within acceptable levels, but adverse effects cannot be completely eliminated.

Because this Final EIS examines alternative programs for treating vegetation, the focus is on how a series of projects conducted over a period of years could affect the environment. From this perspective, there are two areas of potential significant adverse effects: human health risk and degradation of air quality from prescribed burning. The potential for adverse effects varies with each alternative and is discussed in detail in earlier sections of this chapter.

There is the potential for additional adverse effects beyond those described above. The following effects are not expected to be significant; standards, guidelines, and mitigation will be applied:

- Short-term reduction in air quality from dust and engine emissions resulting from vegetation treatment activities other than prescribed burning
- Short-term acceleration of natural rates of sedimentation by soil-disturbing activities associated with the use of heavy equipment
- A temporary increase in fire hazard from waste material (dry vegetation) left on the ground after treatment
- Short-term decrease in habitat for wildlife species (depending on particular plant species and growth changes)
- Damage to soils by compaction from heavy equipment used for vegetation treatments
- Damage or destruction of cultural resources not identified by cultural inventories

- Potential for infringement of the first amendment rights of Native Americans to exercise their traditional religions

Not all of the unavoidable adverse effects that could result from implementing any of the program alternatives can be identified until site-specific projects are identified and environmental assessments are prepared for those projects. Potential unavoidable adverse environmental impacts could include short-term, localized air quality degradation from manual methods that employ power tools, from burning fuels in mechanical equipment, from the smoke of prescribed burning, and from the volatile and drift fraction of herbicides used in chemical methods. However, no air quality standards would be violated.

Adherence to mitigation and operational features built into the program alternatives will minimize the potential for any adverse environmental effects.

ENERGY REQUIREMENTS

Petroleum fuels would be used in all program alternatives to operate aircraft or equipment during vegetation treatment and to transport personnel, equipment, and materials to a treatment area. In addition, small amounts of diesel oil and kerosene would be used as carriers for herbicide application.

The implementation of biological treatment methods would require little fuel; quantities for the manual, mechanical, prescribed burning, and chemical methods would vary depending on the type of equipment used and relative fuel efficiency. In general, aerial application using fixed-wing aircraft is the most efficient treatment method, especially over large areas.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Irreversible Resource Commitment

Irreversible commitments of resources are actions that change either a nonrenewable resource (such as cultural resources or minerals) or a renewable resource to the point that it can be renewed only after 100 years or more. Measures to protect resources that could be irreversibly affected by other resource uses are incorporated into the standards and guidelines of BLM manuals and have been incorporated in the mitigation developed in this Final EIS.

The principal irreversible commitment of resources associated with the treatment of vegetation in the 13 EIS States is the use of fossil fuels. Alternatives that treat more acres would cause higher consumption of fossil fuels. Alternative 1 would require the greatest fuel consumption; Alternative 5 would require the least.

The vegetation treatments proposed can change cultural resources and traditional lifeway values in ways that cannot be anticipated. Since the potential for irreversible commitment of cultural resources generally varies directly with the amount of disturbance, Alternative 5 would probably result in the least commitment and Alternative 1 the most.

Irretrievable Resource Commitment

An irretrievable commitment of resources is the loss of an opportunity for production or use of a renewable resource for a period of time. It is not irreversible because it can be reversed by changing management direction in the future.

The vegetation treatment alternatives in this EIS would result in one irretrievable resource commitment: localized changes in wildlife populations from changes in habitat.

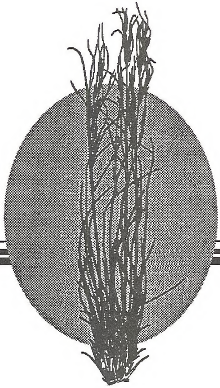
SHORT-TERM USES VERSUS LONG-TERM PRODUCTIVITY

"Short-term" uses are generally those that determine the present quality of life for the public. Short-term uses of public lands in the 13 EIS States include livestock grazing, timber harvesting, recreation, and wildlife habitat. Decisions about these uses are made through BLM Land Management Plans. The program presented here for vegetation treatment is designed for the most part to protect and enhance the long-term productivity of these lands as well as contribute to the short-term uses.

"Long-term productivity" refers to the capacity of the land to support sound ecosystems that produce resources such as forage, wildlife, water, and timber. Vegetation treatments that enhance short-term uses may reduce the natural productivity of some portions of these public lands. The herbicides examined in this Final EIS should have no effect on long-term productivity because most dissipate in the environment relatively rapidly, but other vegetation treatments do have the potential to reduce the natural productivity of the land if certain operating guidelines are not followed. How much the long-term productivity may be reduced is not known because investigations of these effects have only recently begun. The standard operating procedures and mitigation described in Chapter 1 of this Final EIS should minimize the potential for those effects.

Chapter 4

Consultation and Coordination



CHAPTER 4

CONSULTATION AND COORDINATION

PUBLIC INVOLVEMENT

Public involvement and interagency/intergovernmental coordination and consultation are recognized as an essential element in the development of an environmental impact statement (EIS). Public involvement is a critical element for achieving a successful program for the management of public lands and natural resources.

Agencies and interest groups with special expertise or interest in vegetation management were notified of the project and advised of the need to coordinate information. Technical and scientific information available from a variety of sources was reviewed and considered during the scoping process.

Individuals with a specific interest in vegetative treatment may become further involved at the Resource Area level with the Resource Management Plans which will identify general areas of proposed land treatments. Further involvement may occur at the time site specific environmental analysis and documentation are made by making a written request to the local BLM office for those types of actions a group or an individual may be interested in.

SUMMARY

Under the National Environmental Policy Act, Federal agencies are required to seek public participation in the environmental analysis process. Once the decision was made to develop a vegetation treatment environmental impact statement, steps were taken to promptly notify the public of the intent to complete an environmental impact statement and encourage the public to participate in the process. This step is called "scoping." The purpose of scoping is to determine, with input from the public and other agencies (federal and state), including BLM staff, the significant issues relating to the proposed actions to be analyzed in the EIS. Issues not previously identified before the scoping were added to the previously identified issues. In addition, some issues identified were altered or deleted as a result of scoping.

When a project is a multi-State project, the Washington office usually designates the lead State Director. Wyoming's State Director was given the responsibility to lead the project. The next step in the process was to form an interdisciplinary team representing the 13 Western States to be included in the project. The interdisciplinary team members represented the following States: Arizona, Colorado, Idaho, Montana, North Dakota, South Dakota, Nevada, New Mexico, Oklahoma, Oregon, Washington, Utah, and Wyoming.

In addition to serving as technical experts and State contacts for the project, team members played a critical role in the public participation process. Team members assisted in developing techniques and in conducting public meetings to facilitate public participation in the scoping process. They also functioned as liaisons between the team and their individual State Directors and helped to identify the most suitable technique for securing public participation in their individual States.

The team members, together with their individual State Directors, Public Affairs Office, and Planning Division, developed their own method for seeking public participation. Where public response warranted, States conducted public meetings, but all States involved issued press releases informing the public of the intent, purpose, and potential issues involved in the Vegetation Treatment Environmental Impact Statement, and invited public participation.

Members of the public, as well as other agencies or organizations known to be interested in or affected by the proposed action, were identified by the team members with the help of the Office of Public Affairs and the Planning Division from each State involved in the project. Those identified were informed of the public meetings in those states where public meetings were conducted. To help facilitate the discussion during the meetings, fact sheets were provided, and in Wyoming, a video tape was prepared that depicted the different methods of vegetation treatment currently being utilized by the Bureau of Land Management.

The BLM State Directors in the States of Arizona, Colorado, Idaho, Montana, New Mexico, Oregon, Utah, Nevada, and Wyoming represented management responsibility for all the States within the study area. Each State Director had the responsibility of determining the need for public meetings within their respective area of jurisdiction.

PUBLIC PARTICIPATION

On July 15, 1988 the BLM published in the Federal Register a notice of intent to prepare the draft environmental impact statement and conduct public scoping. The public was invited to submit issues, concerns, and alternative treatment suggestions during the 30-day comment period. During the scoping period the BLM conducted thirteen public scoping meetings in the EIS area to provide an opportunity for the public to provide any of their issues and to further inform and discuss the process undertaken with BLM officials.

Scoping meetings were held at the following locations:

Arizona Strip District Office
225 North Bluff St.
St. George, Utah 84770

Safford District Office
425 East 4th St.
Safford, Arizona 85546

Phoenix District Office
2015 West Deer Valley Rd.
Phoenix, Arizona 85207

Yuma District Office
3150 Winsor Ave.
Yuma, Arizona 85364

Boise District Office
3948 Development Ave.
Boise, Idaho 83705

Agricultural Auditorium
New Mexico State University Campus
Las Cruces, New Mexico 88005

Roswell, Public Library
Roswell, New Mexico 88201

Albuquerque District Office
435 Montano Rd. NE
Albuquerque, New Mexico 87107

Sagebrush Inn
Highway 63
Taos, New Mexico 87571

Farmington Resource Area Office
1235 La Plata Highway
Farmington, New Mexico 87401

Riverhouse Motor Inn
Bend, Oregon 97701

Utah State Office
324 South State Street
Salt Lake City, Utah 84111

Casper District Office
1701 East "E" St.
Casper, Wyoming 82601

The BLM received 34 scoping letters, and comments were utilized in the design of the EIS and alternatives considered prior to development of the Draft EIS.

The draft EIS (DEIS) was made available to the public on March 1, 1990, and notices of availability were published in the Federal Register. The BLM provided a 75-day comment period which ended May 15, 1990. However, the comment period was extended until May 22, 1990 to accommodate comments received as a result of a public hearing requested by respondents in the State of Utah. A notice extending the comment period was filed in the Federal Register as well. During the comment period there were fifteen public meetings and one public hearing held. At least one public meeting was held for each state in the study area.

These meetings were held at the following locations:

Public Hearing

Salt Lake County Commission Chambers
2001 South State St.
Salt Lake City, Utah

Public Meetings

Phoenix District Office
2015 West Deer Valley Rd.
Phoenix, Arizona

Anasazi Heritage Center
27501 Hwy. 184
Dolores, Colorado

Grand Junction District Office
764 Horizon Dr.
Grand Junction, Colorado

Colorado State Office
2850 Youngfield St.
Lakewood, Colorado

Boise District Office
3948 Development Ave.
Boise, Idaho

Miles City District Office
West of Miles City
PO Box 940
Miles City, Montana

Lee Metcalf Bldg.
1520 E. 6th. St.
Helena, Montana

Garnet Resource Area
3255 Ft. Missoula Rd.
Missoula, Montana

Public Meetings (Continued)

Holiday Inn
1000 E. Sixth St.
Reno, Nevada

Las Cruces District Office
1800 Marquess St.
Las Cruces, New Mexico

The Riverhouse
State Hwy. 97
Bend, Oregon

Washington County Administration Bldg.
197 East Tabernacle
St. George, Utah

Utah State Office
324 South State St.
Salt Lake City, Utah

Western Wyoming College
Room 1302
Rock Springs, Wyoming

Worland District Office
101 South 23rd St.
Worland, Wyoming

In addition, in an effort to help the public better understand the draft EIS, its alternatives, and treatment methods, the BLM produced a video tape which was shown at the meetings and distributed a fact sheet, along with a question and answer brochure. News releases describing the draft EIS and its availability to the public were sent to the wire services, daily and weekly newspapers, and TV and Radio Stations. The congressional offices in the EIS area as well as numerous interest groups were contacted. Additionally, postpaid reply cards were sent to 1406 individuals in 37 states and another 4,945 cards were used for general distribution to the public in local field offices throughout the study area. These reply cards requested if an individual was interested in receiving a DEIS, and whether they wished to remain on the mailing/distribution list for the FEIS. As a result of these efforts, approximately 5800 copies of the DEIS were printed and sent to individuals and groups. Copies were also sent to BLM offices for general distribution and each governor's clearinghouse. (See Appendix L.)

The BLM EIS team received 411 letters (including testimony received at the Public Hearing) commenting on the DEIS during the comment period. The comments were grouped by resource concern and expertise required to respond. Then an interdisciplinary team prepared responses to the respective comments. Required changes in this FEIS were also developed following this team approach.

A number of letters were received after the close of the comment period (May 22, 1990). These letters could not be included as comment letters because of the late arrival dates. However, concerns raised in these non-timely letters had been aired previously by other commenters and are addressed in this document. Names and addresses of these respondents were incorporated into the overall mailing list and they will receive a copy of the FEIS.

It is important to note that a considerable number of respondents voiced strong support in regards to the quality of the draft EIS document, and BLM's proposed action. These comments were taken into consideration in the preparation of this final EIS. All letters regardless of content were placed in the EIS file of record.

ISSUES/CONCERNS

Some issues/concerns were often repeated by commentors. These general concerns were grouped under the nature of common concern in the EIS section and responded to. Responses to each of the common concerns are provided below. Specific comments/responses are included later in this chapter. Copies of individual letters received are on file and will not be provided in this document.

Common Concern:

Purpose and need section:

Issue: The area covered by the EIS is too large.

Response: The area covered in an EIS is not prescribed or limited by any law or regulation; it is determined by the size of area effected. The area covered in the EIS may be large, but it is designed to provide analysis on a regional basis to properly address the Bureau's treatment programs in 13 Western States. Site-specific analyses will cover smaller areas. (See NEPA Requirements Section in Chapter 1.) BLM has recognized the sizable geographic area identified within the study boundaries, but also refers readers to Tables 1-2 through 1-6 which show that less than 1% of the lands administered by BLM in the 13 State region will be affected by proposed treatment in a given year. This document complies with NEPA and related federal regulations. The regional vegetation and physiographic descriptions in Chapter 2 (Affected Environment) provide a basis for assessing environmental impacts which would occur as a result of the proposed action and alternatives on the natural and human environment.

Issue: The scope of the EIS is too broad.

Response: Legal mandates such as the National Environmental Policy Act, Federal Noxious Weed Act, as amended, and Federal Land Policy and Management Act require analysis, documentation, and public review of proposed actions and that the resulting impacts be disclosed. Full EIS scoping procedure was followed (see earlier explanation in this chapter) and all public input was taken into consideration in the design of the EIS. Scoping also included needs identified in BLM land use plans. The EIS covers issues raised during scoping and if it seems too broad, it is because the EIS covers the breadth of issues raised during scoping. We believe that the scope of the EIS is reasonable and justified given the existing Bureau vegetation treatment program.

Issue: Why aren't EISs being prepared for BLM's vegetation treatment in each State?

Response: An EIS by every state would each address virtually the same issues and actions. Agencies are directed by the Council on Environmental Quality Regulations for Implementing NEPA to reduce excessive paperwork by using program, policy, or plan EISs to eliminate repetitive discussions of the same issues. Agencies are also encouraged to combine proposals and/or actions which are related and evaluate them in a single impact statement. The preparation of an EIS for vegetation treatment in each state would simply increase the time, effort, and cost the BLM 12 to 15 times more with no measurable increase in quality.

Issue: Describe how and when environmental assessment (EAs) will be prepared on site-specific treatment projects and what type of effort is made to insure State and local governments and private interest involvement in that process.

Issue: What is the relationship of this document (EIS) to site-specific treatment project environmental assessments (EAs)?

Response: Site-specific analysis and the appropriate level of documentation will be completed prior to the implementation of vegetation treatments. An Environmental Assessment (EA) would not always be prepared since an EA is only one of several methods for documenting such analysis as provided for in BLM's NEPA Handbook (H-1790-1). Subsequent site-specific analysis and documentation can tier to this EIS, land use plans with supporting EISs, other Programmatic EISs (i.e., Northwest Area Noxious Weed Control Program EIS), and all appropriate activity/project plans with supporting environmental documents which have had the public's input and involvement.

Issue: Some comments indicated the BLM did not meet the NEPA requirements for soliciting public participation in this EIS.

Response: BLM has complied with all NEPA guidelines for public participation in this EIS. Please refer to earlier discussion in this chapter.

Issue: Benefits are skewed toward livestock production, and the document tries to justify livestock forage allocations.

Response: It is not the intent of this EIS to emphasize livestock production or justify forage allocation. The intent of this EIS is to analyze potential impacts of treatments identified in BLM's land use plans. These plans carry out the overall guidance given BLM in various laws including Public Law 95-514 (Public Rangeland Improvement Act) to "manage, maintain, and improve the condition of the public rangelands so that they become as productive as feasible for all rangeland values in accordance with management objectives and the land use planning process..." The land use plan makes land use allocations among the various resources or combinations of resource values, i.e., livestock grazing, wildlife, wild horses and burros, water quality, etc.

Issue: Proposed treatments favor range or livestock with little to no consideration given other programs/resources.

Response: Vegetative treatments are not intended to favor livestock over other resource activities or programs. Much of the Bureau's vegetative improvement guidance is found under rangeland or grazing headings. PUBLIC LAW 95-514 (Public Rangeland Improvement Act, PRIA) defines range improvements to include "any subactivity or program on or relating to rangelands which is designed to improve production of forage, change vegetative composition, control patterns of use, provide water, stabilize soil and water conditions and provide habitat for livestock and wildlife." Design features and mitigation have been expanded in the final EIS describing procedures considering other resource programs (activities) or resources.

Also see Appendix J for references and further discussion of design features.

Issue: Many commentors wanted to know how we determine desired plant community, undesirable plant communities or species, noxious weeds, and target plants, and what uses they are based on.

Response: Strategies and objectives for either maintaining or changing a particular vegetation community are common elements of grazing, wildlife habitat, recreation, forest, and watershed management plans. The concepts of desired plant community,

desirable and undesirable species, and target species are no more than tools which can help a manager set vegetation management objectives and evaluate management progress. A desired plant community is the kind, amount, and proportion of vegetation which best meets land use objectives for a particular site, and which must be within the site's capability to produce through management or a combination of management and land treatment. Desirable plants are species which management seeks to enhance or maintain to meet desired plant community objectives for a particular site. Undesirable plants are species which are not wanted on a site in large amounts from the standpoint of site management objectives. Desirable and undesirable species will vary from site to site, depending on specific site objectives and the combination of land uses that occur in an area.

Target plants are species which may be targeted for biological, chemical, mechanical, or manual treatments in the listed states on selected sites, under certain conditions, to meet specific management objectives on the treatment site. The result is new combinations of species which will better meet management objectives for a particular site. Target plants may include both noxious weeds or native species. Target species which are native plants are generally a desired component of the new vegetation community, but in a different form or abundance than before treatment.

The list of target plant species has been updated in the text (See Appendix I, Section I1). Also, the lists of plant species that have been approved for treatment in the states addressed in the Northwest Area Noxious Weed Control Program (NANWCP) have been duplicated and placed in this EIS (See Appendix I, Sections I2-1, I2-2 and I2-3) to enable a comparison between the target species addressed in both EISs.

A noxious weed, as defined by the Federal Noxious Weed Act (PL 93-629) is a weed that causes disease or has other adverse effects on man or his environment and therefore is detrimental to the agriculture and commerce of the United States and public health. Noxious weeds are designated and regulated by various State and Federal laws. In most cases, noxious weeds are also nonnative species. Noxious weeds are generally considered undesirable species wherever they occur, are often target species for some form of treatment to decrease their abundance and control their spread into unoccupied areas.

Other concerns related to the scope of the document were expressed by commentors who maintained that unspecified aspects of microclimates/ecotones/ecosystems were not addressed in the analysis. Microclimate analysis, relating to how temperature, light, and moisture factors would change, (for example, for a grass plant that was sheltered under a shrub before treatment and exposed after treatment) are beyond the scope of this document except as reflected in analysis of factors which can affect general treatment response in the DEIS, Chapter 3, Section 1, pages 3-5 through 3-29. Ecotone analysis, relating to the gradient that occurs between vegetation types, is dealt with conceptually in the new discussion of vegetation dynamics in the introduction to Chapter 2, and in the individual vegetation analysis region descriptions in Chapter 2. More specific analysis is only possible in a site-specific Environmental Analysis which can address specific juxtaposition of vegetation types where treatments have been proposed. Ecosystem analysis was handled through discussion of impacts to vegetation analysis regions in Chapter 3, which though broad, represent the major ecosystems managed by the Bureau in the Western U.S. and in which the vast majority of treatments proposed in the EIS would occur.

Issue: Importance of the ground water resource as a drinking water supply was underemphasized.

Response: We agree. We have added additional emphasis to the use of ground water as a drinking water supply.

Issue: Water quality concerns should be examined at the project specific level. State agencies for the enforcement of water quality should be contacted. Best Management Practices (BMPs) should be used.

Response: Each state BLM office as well as state water quality regulators have specific on-the-ground procedures for the review of various plans. Some states will require the BLM to have each project reviewed that might impact water quality. Many of the agreements between BLM and state water quality regulators are being developed at this time. The Best Management Practices (BMP) concept will be utilized in most state/BLM agreements. The detail from these agreements will have to be accommodated at the state and local level. Also see the Tiering section for additional explanation.

Issue: Water quality Monitoring must be considered, particularly in relation to BMPs. Monitoring should be placed upstream and downstream where BMPs are to be implemented to document their effectiveness.

Response: Monitoring is an important consideration and generally covered in the Implementation Section under Monitoring. Best Management Practices (BMPs) and other mitigating measures related to water quality will require monitoring according to this section. Specific monitoring attributes will be determined at the site specific level usually in coor-

dination with the state water quality regulator. The BLM intends to use a "feedback loop" process of evaluating BMPs and implementing more effective BMPs where necessary.

Issue: Native American religious and cultural concerns are not being addressed in the EIS.

Response: The Cultural Resources sections of Chapters 1, 2, and 3 have been revised to clarify the BLM's recognition of the need to deal with Native American concerns. In addition, these concerns will be addressed in project specific environmental analysis and appropriate documentation, in a manner consistent with BLM manuals.

Issue: Cultural resources need to be addressed in project specific environmental analyses.

Response: Section 106 of the National Historic Preservation Act, and its implementing regulations (36 CFR 800) require project specific inventory, evaluation, and treatment where needed, before a federal action is authorized. As appropriate, the BLM will comply with these requirements through consultation with the State Historic Preservation Officer and Advisory Council on Historic Preservation.

Common Concern:

Tiering:

Issue: Several letters expressed concern with how this EIS relates to Resource Management Plans (RMPs).

Response: Resource Management Plans (RMP) and their EISs provide the only place where land use allocations for various resource uses (i.e., Areas of Critical Environmental Concern (ACEC), Wildlife, Grazing, Recreation, etc.) are made. This EIS (Vegetation Treatment on BLM Lands in Thirteen Western States EIS) analyzes the combined effect and treatment method alternatives for the vegetation treatment needs identified in the various RMP/EISs prepared by field offices in each state. Please see Figure 4-1, which illustrates the relationship of this level of environmental analysis to the BLM organizational structure.

This is the umbrella or blanket document under which subsequent environmental documents will address specific actions which have a more narrow focus.

Common Concern:

Alternatives:

Issue: Why does the BLM identify the "no action alternative No. 5" as "continue present management" rather than simply "no action as no treatment?"

Response: No change from the current management is considered to be the appropriate no action alternative when ongoing programs initiated under existing legislation and regulations will continue (40 CFR 18027). The no action alternative as presented examines the impacts of management actions and decisions for such ongoing programs in existing Land Use Plans. The alternative of "no treatment" was considered early in this process and not analyzed for this reason.

Common Concern:

Treatments:

Issue: Add tables of treatment by State and treatment method.

Response: Subject tables have been included in the text as Tables 1-2 through 1-6.

Issue: Add tables of treatment by vegetation type.

Response: It was decided to omit these tables, and was concluded that the treatment by state is adequate and will not affect impact analysis.

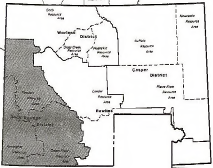
Issue: Correct discrepancies in acreage between tables that are added.

Response: This has been accomplished. A footnote has been added to Table 1-1 indicating that an estimated 25 percent of prescribed burning acreage is a followup treatment to chaining and spraying; thus, total treated acreage would be reduced accordingly.

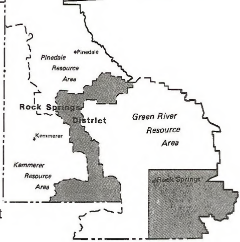
Issue: Explain if acreage figures shown are a quota, maximum, or estimated annual acreage, and how they are dependent upon funding from year to year.

Response: All acreage figures used in this document are an "estimated annual acreage." Several factors may cause a reduction or increases in acreage in any given year, such as available funds, other workloads, revised land use planning, Threatened and Endangered species conflicts, cultural and visual resources and management concerns.

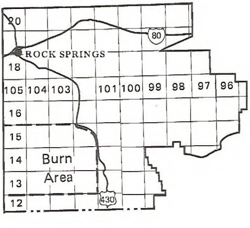
Level 1
Thirteen State EIS Study Area
Regional Level of Analysis:
EIS with broad, regional description of resources and broad, environmental impact analysis. Focuses on general policies.



Level 2
State of Wyoming
BLM Administrative Offices
Statewide Level of Analysis:
Analysis is tiered to level 1 and is prepared for statewide programs. Focuses on the impacts of methods, options, and individual state issues.



Level 3
Rock Springs District and Resource Areas
District or Resource Area
Level of Analysis
Analysis is tiered to either or both above levels. Focuses on impacts of methods and options for specific mult-management proposals (may become level 4).



Level 4
Big Sagebrush Burn Area
Project Level of Analysis:
Analysis is tiered to any or all above levels. Focuses on site specific impacts of implementing a single management proposal.

Figure 4-1
Relationship of EIS to BLM Field Offices

Issue: Why are less acres to be treated under Alternatives 2-5?

Response: The Council on Environmental Quality (CEQ) regulations require that the EIS analyze a reasonable range of alternatives. Alternative No. 1 is the Bureau's proposed action to meet land use objectives, and has a combination of all the different vegetation treatments. Alternatives 2-4 restrict at least one of the different vegetation treatments, therefore reducing total acres to be treated. Alternative 5 is the no action. See Chapter 1, Proposed Action and Alternatives for a complete description of each alternative.

Common Concern:

Cumulative Effects:

Issue: Cumulative effects were not adequately addressed in the draft EIS.

Response: Cumulative impact, is defined in the regulations for Implementing the National Environmental Policy Act as the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

This EIS presents the direct, indirect, and cumulative impacts of all proposed and reasonably foreseeable future BLM actions (described in Chapter 1) that would be implemented on an average annual basis for the intended life of the EIS (10-15 years). The impact assessment presented in this document also takes into account all proposed mitigation (described as design features and/or standard operating procedures).

Typically, the effects of past actions (BLM actions, as well as, actions of others) is accounted for in the description of the Affected Environment. This description serves as the baseline depicting current conditions, including trends in those conditions, as they exist just prior to the initiation of the proposed action or any alternative.

Discussion of cumulative impacts resulting from BLM actions and like actions (both present and reasonably foreseeable) of others is presented when such impact analysis is considered essential to making a reasoned choice among alternatives.

This EIS is a programmatic document and is intended to be tiered with existing Land Use Plan/EISs and subsequent site-specific analysis and documentation for site-specific projects when proposed. The cumulative analysis documented and tiered with in all such applicable documents is considered during the site-specific decision making process.

Common Concern:

Herbicide effects on wildlife:

Issue: Changes in the structure of vegetation, by the various treatment methods, will have a negative impact on the existing wildlife populations.

Response: An obvious impact of any treatment is the change in the vegetation structure before and after treatment. This vegetation community change, if intended to be permanent, or long-term, will result in a permanent, or long-term, change in the resident wildlife species. Some of these treatments are intended to restore past vegetation communities and would result in long-term changes in wildlife communities, hopefully restoring an historic wildlife community. The analysis of these long-term changes must consider the overall impact and significance of eliminating or replacing existing communities, and adding new wildlife communities, especially when special status species are involved. Some structural changes are much less dramatic than full community conversions and result in subtle changes and shifts in the wildlife community composition. The expected new community is weighed against the species being adversely impacted and the impacts weighed.

Issue: Use of herbicides is (1) detrimental to wildlife, (2) no herbicide treatments should be done, (3) especially no aerial application of herbicides should be allowed.

Response:

(1) As a public land management agency, we make use of the best information available to make management decisions. We will only use herbicides that have been researched and tested and found to be acceptable by current standards for the proposed use. We will choose the herbicide that is the least impacting to the wildlife community in the treatment area and while still being effective against the target plant species (mitigation, Chapter 1).

(2) We understand that tests on wildlife have been performed according to the existing regulations and the results have been appropriately interpreted, therefore, the label restrictions will be

accurate and safe. We acknowledge the potential for adverse impacts to wildlife from improperly applied herbicides. However, these adverse impacts can be mitigated, and that will be the approach used within the BLM to protect wildlife species from herbicides.

(3) In the Final EIS we have added mitigation to lessen the possibility of an adverse impact to wildlife. Specific mitigation has been expanded to strengthen the protection of riparian and aquatic areas (Chapter 1). Buffer zones are already required in the BLM's Chemical Pest Control Handbook, H-9011-1, which regulates our use of herbicides. The use of helicopters and maximum spray control nozzles will assure a greater degree of control of the specific areas receiving aerial applications. In ground applications the degree of control is always much greater.

To minimize impacts to fish and other aquatic wildlife, amitrole and dalapon are no longer proposed for use. Atrazine, clopyralid, diuron, simazine, triclopyr (butoxyethyl ester only), 2,4-D, or diesel oil carriers will be very carefully regulated and applied when the treatment area is adjacent to aquatic habitats. The required buffers and the use of the least toxic herbicides will minimize the potential impacts of herbicide spraying on aquatic systems. Without accidents there should be no impacts. It is our intent to minimize the unexpected adverse impacts under all treatments and alternatives.

Issue: Amphibians were not adequately addressed in the risk assessments. What is the impact of Tebuthiuron on amphibians?

Response: Research published by the Fish and Wildlife Service covering a comprehensive analysis of acute toxicity of 410 chemical pesticides on 66 species of freshwater animals (Mayer, F. L., Jr., and M. R. Ellersieck. 1986) found the amphibians, as a group, to be the least sensitive of all groups of organisms. Fish are generally 2 to 3 times more sensitive to herbicides than amphibians. Research on the effects of tebuthiuron on bullfrogs (R. Meyerhoff, personal communication. 1990) showed them to be 2 to 3 times more resistant than rainbow trout and bluegill. Therefore, our assumption is that if we protect the aquatic and wetland areas to prevent impacts to fish, we will be very safe for amphibians.

Issue: The risks of using herbicides on wildlife habitat were not adequately addressed in the impacts analysis. Are the herbicides accumulated in the food chain?

Response: As indicated in our analysis of impacts, the most toxic applications of herbicides occur in conjunction with maintaining rights-of-ways and oil and gas facilities. Fortunately these are very small acreages compared with the rangeland and other proposed applications. None of the chemicals being proposed were found to be bioaccumulative. Except in extreme situations there does not appear to be any real threat to wildlife from the proposed applications of herbicides. The higher risk situations must be monitored on a local level to assure that no significant impacts to wildlife are occurring.

In order to understand the potential impacts of our proposed actions, both the analysis of impacts of the proposed treatments in the final EIS document and the risk analysis in the appendixes should be reviewed. Appendix E, sections 6, 7, and 8 are a summary of research on the physiological toxicity on terrestrial and aquatic wildlife, for the 19 herbicides being proposed for use. This analysis is the basis for determining the likely adverse toxic impacts of our proposed actions on potentially impacted wildlife species. In the Final EIS, additional discussions of the potential adverse impacts of herbicides to wildlife, as a result of our proposed actions, have been incorporated. On the basis of these potential adverse impacts, mitigation has also been proposed that would significantly lessen the likelihood for these possible adverse impacts to occur.

Common Concern:

Economic analysis:

Issue: Many people asked for a copy of the Economic Impact Statement on Vegetation treatment of BLM lands.

Response: Regulations do not require a separate document from the EIS on economic impacts. Economic impacts for the proposed action and alternatives are discussed in the EIS. See Chapter 3, Section 1.

Issue: The EIS should consider the economic impact of the loss of the pinyon pine on local communities that collect pinyon nuts for food.

Response: Chapters 1, 3, and 4 have been revised to consider pinyon nut use by Native Americans. This and other nut uses should be covered in land use plans and the effects of treatment will be considered in project specific analyses and environmental documentation.

Issue: The proposed treatments are not cost effective and would not yield any return on investment.

Response: The BLM is not required to conduct Benefit/Cost analysis of alternatives in a programmatic EIS. The BLM Manual Handbook H-1740-1, Renewable Resource Improvement and Treatment Guidelines and Procedures, presents procedures on when and how to conduct investment analyses. This handbook provides general and program specific guidance about when or what investment analysis is required or recommended.

In accordance with this guidance, after the EIS and when specific treatments are proposed, an investment analysis will be conducted. This analysis might be for the specific treatment proposed or for groups of actions as in a resource management activity plan.

Common Concern:

Biodiversity:

Issue: Many commentors expressed concern of the effects of proposed vegetation treatments on biodiversity, or took issue with impact analysis which stated that diversity could be improved in some situations by vegetation treatment.

Response: Vegetation treatment can affect vegetation diversity, as the term is used in the Chapter 3 impact analysis, by changing the number and kinds of species or life-forms, the mix of age and size classes, and distribution of vegetation communities on the landscape. Diversity in this sense, the variation of these kinds of characteristics, may be enhanced by vegetation treatment. The discussion is about vegetation, not the whole realm of organisms and interactions that encompass biological diversity as defined in the Glossary of the Final EIS. The introduction to Chapter 2 in the Final EIS discusses the role of disturbance of various kinds and magnitudes in shaping the past and present of the vegetation analysis regions.

Certain treatments can be said to enhance diversity by restoring historic native vegetation as much as possible, such as when riparian areas are reclaimed from tamarix, when sagebrush and perennial grass are established in cheatgrass stands, or when grassland cover is reestabished on brush-dominated semidesert grassland. Aside from whether there are more or fewer species present after these kinds of treatments, such treatments contribute to restoration and maintenance of native ecosystems, and as such are considered to contribute to maintenance or restoration of vegetation diversity.

In response to changes made in the vegetation communities by the vegetation treatments and the results summarized above, the animal communities may also exhibit increased diversity through the creation of new habitats and edges to the previously existing habitats. Any change from the previous situation will result in new habitats and niche combinations that will be suited to a new community of animals or different combinations and relative abundance of existing animal populations.

These changes will be considered prior to any planned treatment. If the predicted change in the existing community is significantly detrimental to the welfare of existing animal populations, the project can be modified or cancelled. If the project would not have a significant negative effect on existing populations or would be beneficial to existing populations or create new habitat for other species, then the project would be beneficial to the diversity of species in the area. It is this analysis process on specific project proposals that assesses the detrimental and beneficial impacts to biological diversity, determines the proper course of action, and best management practices for the situation. The relative abundance and status of the species (e.g. special status species) must be strongly considered during this analysis.

Negative impacts on animal species diversity could occur in situations where existing habitat was in short supply and the treatment would significantly reduce this habitat. However, in situations where the existing habitat was extensive and dominating, the creation of variation in this habitat through vegetation treatment would result in creating habitat edge and a new type of habitat, which could increase the diversity of the biotic community within the original area.

The special status species screening process is intended to protect the rare plants, animals, and their habitats, that contribute to biological diversity at the genetic and species level. As maintenance of biological diversity in the broader sense depends on maintenance of ecosystem functions and interactions, local disturbances and modifications from treatments can have varying effects. It is a complex situation to analyze and requires consideration of a variety of factors during project planning, such as size and placement of treatment relative to total available habitat at local or regional scales, and others which are still being researched, such as organisms or species groups that indicate critical points in ecosystem health.

Common Concern:

Risk analysis

Issue: There was inadequate coverage of the potential for ground water contamination from herbicide application.

Response: We agree that the potential for ground water contamination from herbicides was not adequately addressed in the draft. We have incorporated several additions to the sections to address the ground water concerns. See Chapter 3, Section 1.

Issue: Several of the aquifers in the DEIS area are inherently susceptible to leaching and contamination.

Response: We agree that the potential does exist in some areas. We did not intend to dismiss the potential. Rather, the impacts associated with a high potential area would have been avoided through the application of design features. We envision that the procedures would likely be adopted as Best Management Practices (BMPs) by the appropriate state agency. These practices have been included under Mitigation. Also see Figure 2-8.

Issue: Eight of the 19 herbicides proposed for use by BLM are ranked as having high leaching potential... The EIS should provide additional information on this concern.

Response: The DEIS listed very few data on the leaching potential of pesticides. Information has now been included where it is available. The Surface Water Impacts and the Ground Water Impacts in the Chemical Methods of the Environmental Impacts Section have been rewritten to reflect the leachable pesticides identified in EPA (1987).

Issue: Many of the herbicides are not included in EPA drinking water standards. It is wrong to mislead the public into thinking that there are strict drinking water standards for these herbicides.

Response: We agree that there are many compounds for which drinking water standards are not developed. We do not believe that anything in the statement about drinking water standards implies that there are strict standards for herbicides. Monitoring standards may be established by the state water quality regulator. Based on our standard operating procedures, any herbicides from our operations reaching the ground water in any significant level causing environmental or health effects would be unacceptable.

Common Concern:

Emphasis of noxious weed program

Issue: Not enough emphasis was addressed on noxious weed management.

Response: The text has been revised to address the noxious weed management program to a greater detail. See chapter 1 sections Program Objectives, Weed Management Treatments and Design Features, Treatment Method Descriptions (Biological and Chemical).

As a concept that uses a variety of techniques to control unwanted plants or animals, integrated pest management (IPM) implies that all available chemical treatment methods could be used. Both effectiveness and economic efficiency would be considered in making options. A high proportion of the expected control acreage is proposed for the spraying of herbicides because existing information on infestations and the relative effectiveness and costs of possible control programs reveal that spraying is the best way to achieve a reasonable amount of control. Research into alternative techniques will do the job in some of the situations now proposed for herbicide spraying. Because the Proposed Action is an IPM alternative, alternatives to herbicides would be adopted when and where they are found to be effective and efficient.

Issue: In Appendix I, not all weed species are listed in some states.

Response: See revised Appendix I-1.

Issue: Biological control agents should be used more.

Response: The biological control methods section has been expanded in the text. Three lists concerning biological control agents have also been added in Appendix C (2 thru 4).

As biological control agents become available, BLM will continue to increase their use. Estimated costs to develop a biological control program per weed species are often expensive. Usually a complex of at least three to five different biological control agents, such as insects, must be used to attack an individual weed species infestation site. This includes different agents that feed on the blossoms or seed heads, leaves, stems and root systems. In addition to the need for a complex, often 15 to 20 years are needed to bring about an economic control level, especially on creeping perennials.

SPECIFIC COMMENTS AND RESPONSES

Each person, organization, or agency that provided written comments are listed in Appendix K.

Figure 4-2 depicts the summary of responses received in regards to the Alternatives presented in the Draft EIS. Figure 4-3 depicts the number of responses received on the DEIS by respondents in each state.

As each comment (including letters, testimony from public hearings, and written comments submitted at public meetings) was received, it was assigned a sequential identification number according to its state of origin (i.e., the first letter received was from Utah, and was designated UT-0001). However, some letters were assigned numbers in the 2500 and 5000 series for data entry purposes. Each comment letter was placed in the EIS file by numerical sequence. Appendix K is a listing of respondents with respective identification numbers.

Where possible, public concerns were addressed in the common concerns section. Specific comments needing a more in-depth response follow:

NM-0038, Thomas H. Wootten.

Comment: "Impacts on wildlife discussed in the EIS do not include important segments of the indicated ecosystems. No where do I see mentioned the potential impact on amphibians, reptiles, and insects (especially ground dwellers such as ant and termites) and arthropods. These are important parts of any ecosystem."

Response: The scope of this document is broad. The discussions of wildlife communities focus on the those communities which have the best documentation of impacts, those with the greatest economic impacts, the species for which we are most likely to perform habitat treatments, and special status species. The small wildlife species are too numerous, varied, and generally too poorly studied to make specific statements of potential impacts on the scale of this EIS. These other species are not overlooked, however, a site-specific analysis will be performed on each of the proposed treatments on public lands prior to implementation. These site-specific analyses should consider all species of wildlife that are determined to be impacted by the proposed action, regardless of visibility, public interest, or status.

AZ-0052, Dan Fischer.

Comment: "Prescibed burns is a problem because most fires are set in spring and summer mainly for your convenience. This might be because of budget, fire crew buildup, etc. This is also the bird nesting season. The fall would be more acceptable from that viewpoint."

Response: Statements have been added to mitigation (Chapter 1) and in the summaries of the impacts (Chapter 3) of mechanical, prescribed burning, and chemical treatments.

NM-0066, Martha Cast.

Comment No. 1: "On Exec-5, under Climate and Air Quality, the statement that 'local residents are acclimated to these sounds' is certainly not reasonable. Just because there is air traffic all over the West, that does not mean that people or animals living in or near areas to be treated aerially are accustomed or willing to adapt to having low-flying aircraft dispersing noxious chemicals for the crop dusters and low-flying military aircraft that pollute my local airspace manage to scare people and animals on a daily basis; we still are not acclimated."

Response: The Bureau concurs. The statement has been removed.

NM-0066.

Comment No. 2: "Although no riparian areas are to be treated by aerial chemical application, there will be many semi or xeri-riparian areas in the bottoms of small arroyos that will be affected."

Response: Mitigation has been added for protection of xeroriparian areas for wildlife (Chapter 1).

NM-0066.

Comment No. 3: "Why is BLM proposing to use tebuthiuron which has a long persistence in soil, but has no long term studies done on any mammals and has no studies on amphibians or reptiles?"

Response: Page E6-11 of the DEIS indicates that a 3-generation rat study and a 162-day cattle study were performed using tebuthiuron. The top of column 2 on page E8-1 of the DEIS states that

Summary of Letters Received by State

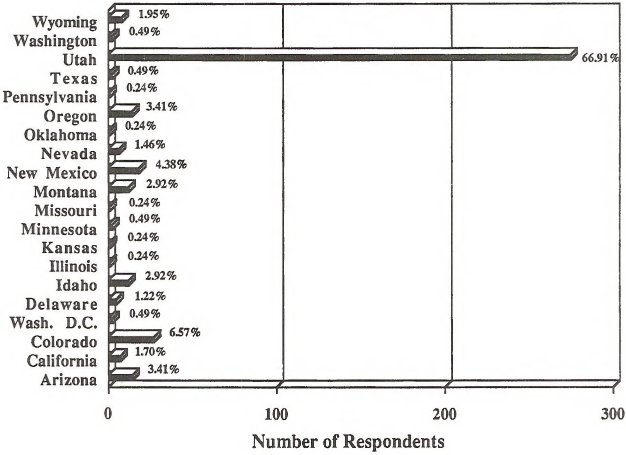


Figure 4 - 2
Summary of Letters Received by State

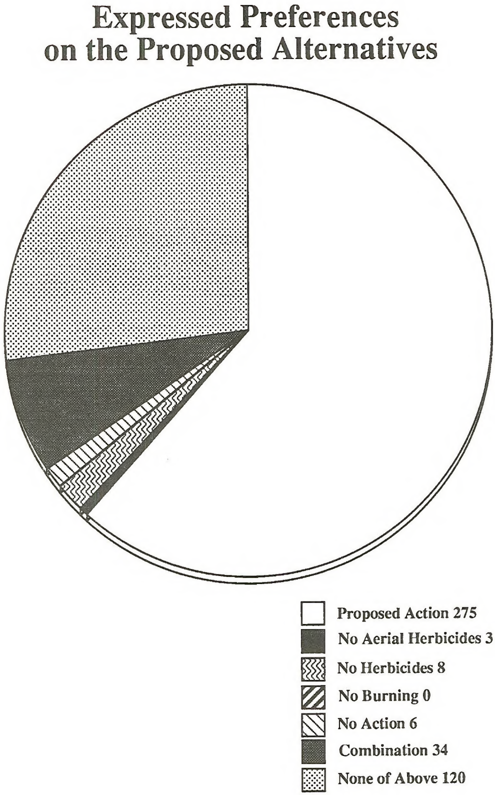


Figure 4 - 3
Expressed Preferences on the Proposed Alternatives

chronic wildlife studies were not analyzed because the herbicides degrade relatively rapidly and the sites are normally treated only once a year. On the same page is a criteria used for Surrogates for Amphibian and Reptile Toxicity.

NM-0067, Steven M. Cather.

Comment: "In summary, I feel the draft EIS does not adequately address the long-term effects of vegetation treatment on areas that may be adversely impacted by increased sediment yields and resultant channel aggradation."

Response: Site-specific treatment design should incorporate sufficient mitigation to assure significant overland flow does not occur in situations where a significant fisheries or riparian resource would be adversely impacted. Standard Operating Procedures and Treatment Design Features found in Chapter 1 have been written to respond to potential adverse impacts to riparian and aquatic resources should unusual situations occur. Treatments will be avoided in the circumstances you describe, as mitigation of surface run-off would be very difficult to control.

NM-0073, Jeanne Verploegh.

Comment No. 1: "Some herbicides are not suited for certain environments. Soil types, vegetation and wildlife should be considered for the application of each herbicide. The EIS should state which herbicides would be used for which of the above-mentioned items."

Response: See Toxicity and Environmental Fate summaries for each herbicide (Chapter 1).

NM-0073.

Comment No. 2: "Page Exec-7 of the EIS states that effects of vegetative treatment will be minimized. Several of the herbicides kill more than only target species. Mechanical and burn treatments are even less selective."

Response: The basic philosophy of vegetation management and treatment is based on the premise that knowledge of ecosystems, succession, and the application of the results of research and experience can be used to improve the condition of degraded lands or areas invaded by noxious plants. No treatment is proposed unless there is an existing problem that appears to be correctable through vegetation treatment and improved management following treatment.

The term "minimal," when used in the context of analysis of impacts of a treatment, refers to creating the least possible disruption in the existing functioning of the ecosystem necessary to achieve the planned objectives of the treatment project, not that there will be no effects or impacts.

Each proposed treatment will have a site-specific analysis conducted prior to on-the-ground implementation. These analyses consider the beneficial and adverse impacts of conducting the proposed treatment and whether to proceed with the proposed action, modify the proposed action, or drop the proposal.

NM-0073.

Comment No. 3: "You need to explain why **one** species, like antelope, should take precedence over **many** species of amphibians and reptiles for habitat."

Response: The impact that will occur as the result of a particular land treatment must be analyzed in the site-specific environmental analysis. The responsiveness of wildlife communities to recover after treatment is one of the factors to be considered. The advantage to the benefiting segment of the wildlife community should be at least as significant as the loss by the community displaced or disrupted. And, the loss should not be significant to the whole of the species impacted, nor should habitat for a special status species be lost in favor of habitat for a common species.

NM-0073.

Comment No. 4: "The EIS contains no information on the long term effects of the chemicals, or the effects from long term exposure to the chemical's break-down products."

Response: See Appendix pages E3-16 to 61 for data on the subchronic and chronic toxicity studies for the individual herbicides. Also, see new data presented in Chapter 3 impact analysis in the Soil and Aquatic Resource section and Table 3-3 for soil persistence information.

NM-0076, Curtis Verploegh.

Comment No. 1: "Although normally dry arroyos do not meet your definition of riparian, the woody plants that grow there provide cover and nesting sites. As mentioned in another comment no effort has been made to miss any but the very largest drainages. This is a practice that needs to be addressed."

Response: (See response to NM-0066 Comment No. 2.)

NM-0076.

Comment No. 2: "The breakdown products have not been investigated and should be."

Response: Since the risk assessment includes analysis of synergistic effects, it is recognized that more than just the parent is possibly present in any given situation.

NM-0078, Robert Pine.

Comment No. 1: "There is a large potential for negative impacts to wildlife (by wildlife I mean more than game animals; I also include reptiles, insects, microbes and any organism that plays an ecological role in an ecosystem."

Response: As a public land management agency we make use of the best information available to make management decisions. We will only use herbicides that have been researched and tested and found to be acceptable by current standards for the proposed use. We will choose the herbicide that is the least impacting to the wildlife community in the treatment area while still being effective against the target plant species. If EPA withdraws registration, the herbicide is not safe for the previous labelled use and we will discontinue that use.

NM-0078.

Comment No. 2: "...no consideration was given to the persistence of the listed herbices or to the toxicity of their breakdown products."

Response: See FEIS Appendix, page E8-1, top of the second column for a discussion of persistence, and see Table 3-6 in the FEIS for soil persistence. Since the risk assessment included a quantitative analysis of synergistic effects, it is recognized that more than just the parent compound is possibly present.

UT-0079, Ronald M. Lanner.

Comment: "It appears to me that chaining and 'converting' woodlands is in direct opposition to managing them as forests [as discussed by David Tidwell and Edward Spang in papers on BLM policy which appear in the *Proceedings—Pinyon Juniper Conference*, Reno, NV, January 13-16, 1986, General Technical Report INT-215, 1987, pp. 5-8 and 489-492].

Response: The papers cited do indeed indicate that the millions of acres of pinyon-juniper woodlands managed by BLM are considered as part of the forest land resource. By this, we mean that BLM recognizes the distinct and important values of woodlands as a forest land resource, that they can be managed with various forestry and silvicultural techniques, and that the value of these woodlands as a forest resource must be weighed in any decision to manage them as non-forests. It is still the province of a local manager, through a land use plan, to determine whether local land use objectives will be better met by converting a woodland site or by leaving it in woodland.

Type conversion of woodlands is a site-specific land use decision, based upon the kinds and levels of land uses agreed to in the land use plan, economics of any proposed conversion, site capability to support a different mix of vegetation, and values realized by type conversion vs. values diminished or foregone. Type conversion of pinyon-juniper as currently practiced leaves islands of trees and results is a mosaic of vegetation that does not preclude restoration of forested cover should that become the desired plant community for a converted site at some time in the future.

The relatively small amount of type conversion proposed in the EIS should not detract from the substantial remaining acreage which is being maintained as a legitimate forest type.

WY-0085, Thomas E. Marceau.

Comment: "Cultural resources need to be addressed in project specific environmental analyses."

Response: Section 106 of the National Historic Preservation Act, and its implementing regulations (36 CFR 800) require project specific inventory, evaluation, and treatment where needed, before a federal action is authorized. As appropriate, the BLM will comply with these requirements through consultation with the State Historic Preservation Officer and Advisory Council on Historic Preservation.

NV-0086, Alice M. Baldrica.

Comment: "Cultural resources need to be addressed in project specific environmental analyses."

Response: See response to WY-0085.

AZ-0088, Dennis W. Sundie.

Comment 1: "...Of course, we have observed that your document briefly discusses surface water and

groundwater conditions in the various vegetation zones, and does not mention any impacts on water yield. Although our study focuses on the chaparral, mixed conifer, and ponderosa pine vegetation communities, the process by which we estimate effects on multiple resources may be of interest to BLM."

Response: Such information would be of great value in assessing site specific actions and selecting Standard Operating Procedures and Best Management Practices. District Offices responsible for the preparation of such site specific assessments would likely contact your staff as projects are planned.

WA-0094, Sam Wright.

Comment No. 1: "...under Fish and Wildlife' in Table 1-4 (page 1-27), the statement under Alternative 1 begins with No significant impact on fish. ' However, Alternative 2 is described in part as less risk to fish from herbicide drift' and Alternative 5 carries the partial description of less overall impacts than Alternative 1....'"

Response: The Summary of Impacts by Alternative Table 1-9 (Table 1-4 in the DEIS) has been revised.

WA-0094.

Comment No. 2: "...in the paragraph under the heading Chemical Methods' on page 3-53, we note the following admission: Near riparian areas, using chemicals to control vegetation can increase sedimentation, which can reduce or eliminate suitable spawning substrate.'"

Response: The statement on page 3-53, and similar discussions, have been qualified to state that even though these impacts would be possible, they should not occur because we will modify or mitigate our proposed action to prevent this degree of impact.

WA-0094.

Comment No. 3: "We also recommend that any herbicide uses in or near habitats supporting anadromous fish should be delayed until after June 15 of each year. This would allow adequate time for the yearling salmon smolt populations to vacate these areas."

Response: Your suggestion has been incorporated into mitigation section in Chapter 1. The June 15 date was not specifically included because the sensitivity period of species may vary over the EIS area. We have also strengthened the treatment of fisheries throughout the document.

MT-0095, K.L. Cool.

Comment No. 1: "The summary of impacts by alternative suggested that introduction of significant amounts of herbicides into streams would be unlikely. Thus, no significant impacts to fish were anticipated. This may be correct, but in the unlikely event that herbicides were introduced, impacts to fish would be significant. Additional mitigation measures to reduce the likelihood or to abate the effects if an introduction occurred would include: (4 mitigation measures recommended)."

Response: These suggestions have been incorporated into the document as design features in Chapter 1. We have also strengthened the treatment of fisheries throughout the document.

MT-0095.

Comment No. 2: "The DEIS suggested that adverse impacts to wildlife would be short-term and localized. This describes wildlife response to effects of the treatment. However, the treatments are intended to change the composition of plant communities. The long-term effects to wildlife will depend upon the purpose of the treatment and whether it was successful."

Response: Additional discussion has been added in the analysis of alternatives to reflect the intended permanency of some habitat type conversion treatments.

MT-0095.

Comment No. 3: "Reduce frequency and rates of application of herbicides by timing application to the vulnerable phenological events of the target plant species."

Response: Refer to Chapter 1, Standard Operating Procedures section, on frequency and rates of application of herbicides by timing application to the vulnerable phenological events of the target plant species.

OR-0097, George Ostertag.

Comment: "The BLM should be trying to remove the environmental damage from planting this exotic [crested wheatgrass] and not be worrying about controlling native vegetation. Any planting of exotic species should be halted."

Response: BLM policy regarding introduction of exotic species requires evaluation of whether native species will be displaced or adversely affected, anal-

ysis of potential impacts to biological and genetic diversity of potentially affected native species, and determination that a proposed introduction will not adversely affect any natural ecosystem. BLM is not aware of ecological studies which show that crested wheatgrass has caused environmental damage in western ecosystems by displacing and excluding native species or invading unoccupied sites by natural spread. Such behavior is well documented for other exotic species such as cheatgrass, medusa head, and tamarix. Throughout much of the intermountain west, crested wheatgrass is the only native or nonnative cool season grass adapted to local climatic conditions, available at reasonable cost, which meets local land use plan objectives for spring-fall forage or fire resistance, which can also be seeded and successfully established. A number of other nonnative species are listed as target species in Appendix I.

UT-0104, Don A. Ostler.

Comment No. 1: "We suggest that best management practices (BMPs) be in place before, during and after any vegetative treatment that may cause degradation of water quality."

Response: Each state BLM office as well as state water quality regulators have specific on-the-ground procedures for the review of various plans. Some states will require the BLM to have each project reviewed that might impact water quality. Many of the agreements between BLM and state water quality regulators are being developed at this time. The BMP concept will likely be utilized in most if not all state/BLM agreements. The detail from these agreements will have to be accommodated at the state and local level. The responses under the Tiering section review some of the hierarchy within the BLM's planning process and points out avenues that state agencies and the public can use for input into the project-specific process.

UT-0104.

Comment No. 2: "We suggest that measures need to be taken to protect the riparian habitat in all areas where it may be affected. Riparian areas not only provide habitat for varieties of wildlife, they also provide stream bank stability and a buffer for water quality degradation."

Response: Discussion of riparian issues has been expanded in Chapter 1 and throughout the document where appropriate.

UT-0104.

Comment No. 3: "We suggest water quality monitoring above and below installed BMPs to document effectiveness and where BMPs are shown not effective that they are altered until proven effective."

Response: Monitoring is an important consideration and generally covered in the Implementation Section under Monitoring. BMPs and other mitigating measures related to water quality will require monitoring according to this section. Specific monitoring attributes will be determined at the site specific level and is usually in coordination with the state water quality regulator. The BLM intends to use a "feedback loop" process of evaluating BMPs and implementing more effective BMPs where necessary.

NM-0105, Gregory D. Rawlings.

Comment: "I would also be interested in knowing the special management practices for Areas of Critical Environmental Concern and Wilderness Study Areas."

Response: Special management practices for designated Areas of Critical Environmental Concern (ACECs) are identified in approved Resource Management Plans, which outline general management practices and uses as well as mitigating measures required to protect designated ACECs. Detailed or expanded special management practices may also be prescribed in management or activity plans which may subsequently be prepared after formal designation of ACECs. Special management practices for Wilderness Study Areas are described in the Bureau's Interim Management Policy and Guidelines For Lands Under Wilderness Review (Update Document H-8550-1 dated 11/10/87), a copy of which may be obtained from any BLM office. See also, pages 1-24, 1-25, 3-62, and 3-63 of the Draft EIS.

NM-0106, Jim Platt.

Comment No. 1: "Project specific information will be necessary to determine possible impacts. BLM recognizes this in the EIS, they should explicitly state that all projects conducted under the program must meet State water quality standards as well as other State regulatory requirements. Other comments are relative to herbicides, sediment and State of New Mexico water quality standards."

Response: See responses to UT-0239, and UT-0104.

NM-0106.

Comment No. 2: "In this EIS, BLM several times makes the comment that increased sedimentation of surface waters due to vegetation treatments will have short term effects. BLM should note in this EIS that all activities carried out must be consistent with State nonpoint source management programs developed pursuant to the federal Clean Water Act. In New Mexico, protection of water quality will be required so that short term violations of standards do no occur."

Response: Short term increases of sediment in surface waters due to vegetation treatments does not imply that state water quality standards will be violated. BLM compliance with individual state water quality standards will be adhered to as stated on page 1-29, paragraph 8 and page 1-30, paragraph 10 of the Draft EIS.

AZ-0107, Ronald L. Miller.

Comment No. 1: The comments are concerned with water quality. "ADEQ therefore requests that the Bureau of Land Management submit to the Department, site specific plans for any vegetation treatment in Arizona for CWA Section 401(a) certification review."

Response: See responses to UT-0239, and UT-0104.

AZ-0107.

Comment No. 2: "Water quality concerns should be examined at the project specific level. State agencies for the enforcement of water quality should be contacted. Best Management Practices (BMP) should be used."

Response: See response to UT-0104.

AZ-0107.

Comment No. 3: "The Arizona Department of Environmental Quality, (ADEQ) has reviewed the Draft Environmental Impact Statement on Vegetation Treatment on BLM Lands and concluded that all alternatives represent significant potentials for unacceptable impacts to both Water and Air Quality."

Response: The DEIS states on Page 1-30 (State and Local Governments) "The act [FLPMA] also requires BLM to provide for compliance with applicable pollution control laws, including State and Federal air and water pollution standards or implementation plans." On Page 3-30 (Impacts on Air Quality), the DEIS states "Federal, State, and local air quality regulations would not be violated." Specifically, if compliance with Federal and Arizona air quality regulations still represent unacceptable air quality impacts, the Bureau will assist in development of new State regulations.

AZ-0108, Ivan J. Shields.

Comment No. 1: "7. Chemical applications: All chemical applications must be done in compliance with Arizona law. This may include obtaining Special Local Need registrations and meeting Arizona requirements as far as spraying chemicals in such a way as to avoid drift and contamination of crops, animals or people."

Response: See response to AZ-0107, Comment No. 3.

AZ-0108.

Comment No. 2: "Cultural resources need to be addressed in project specific environmental analyses."

Response: See response to WY-0085.

DE-0110, Martin J. Reid.

Comment: "The section titled "Program Areas" the reasons for vegetation control along right-of-ways, including railroads, are listed. These reasons include the need to eliminate vegetation which "restricts vision" or that "presents a safety or fire hazard." I would like to suggest that vegetation control is a **critical** part of safe railroad operations and is important for many more reasons."

Response: See revised text in Chapter 1, Right-of-Way Treatments. We acknowledge the importance of vegetation control and importance of chemical vegetation control on railroad rights-of-way.

MT-0112, David Schwab.

Comment No. 1: "Native American religious and cultural concerns are not being addressed in the EIS."

Response: The Cultural Resources sections of Chapters 1, 2, and 3 have been revised to clarify the BLM's recognition of the need to deal with Native American concerns. In addition, these concerns will be addressed in project specific environmental analysis and appropriate documentation, in a manner consistent with BLM manuals.

MT-0112.

Comment No. 2: "Does BLM intend to address the issue of herbicide application impacts on traditional plant collection activities by Native Americans?"

Response: Tables E5-3 to E5-15 present exposure scenarios for members of the public. Table E4-1 has been revised to include Native American gatherers.

OK-0113, Robert L. Brooks.

Comment No. 1: "Native American religious and cultural concerns are not being addressed in the EIS."

Response: See response to MT-0112, Comment No. 1.

OK-0113.

Comment No. 2: "Cultural resources need to be addressed in project specific environmental analyses."

Response: See response to WY-0085.

UT-0114, Peter Hovingh.

Comment No. 1: "Often one only looks at maps of distribution and states that no known species of T&E status occur in the region. Areas proposed for treatment should have at least a full year announcements [sic] together with some funding for biological surveys. Plants in arid regions may be dormant for many years but come out of the ground during a triggering rainstorm or after a triggering fire. Likewise plants of special status are often highly seasonal and one survey of the land is not adequate."

Response: Determination of presence or absence of special status species in a proposed project area is part of the environmental analysis process. Where distribution maps, previous inventory, known habitat affinities, or new information obtained from other agencies indicate a high probability that T&E species may be present in a proposed project area, an actual site examination is normally conducted. If a species is cryptic because it is an annual or for some other reason, this must be accounted for in the environmental analysis process. It is the responsibility of the botanist, wildlife biologist, or T&E coordinator to conduct a field survey at such time that the species can be properly identified, and a proposed project can be delayed until proper field survey has provided assurance of presence or absence of special status species. The environmental analysis process is not complete until special status species concerns have been satisfied, and a project is not undertaken without finalized environmental documentation.

UT-0114.

Comment No. 2: "Page 2-42 and 2-48: References to amphibian abundance are misleading."

Response: The discussions of aquatic species and invertebrates in the final EIS have been revised. Refer to Chapters 2 and 3.

UT-0114.

Comment No. 3: "Some of the herbicides are clearly highly destructive to aquatic organisms. It seems that these herbicides should not be included in treatments even if barriers to use on aquatic systems occurs."

Response: Mitigation has been expanded to strengthen the protection of riparian and aquatic areas (Chapter 1). Buffer zones are required in the BLM's Chemical Pest Control Handbook, H-9011-1, which regulates our use of herbicides. The use of helicopters and maximum spray control nozzles should assure a greater degree of control of the specific applications. In ground applications the degree of control is much greater. A list of herbicides to be avoided in aquatic impact situations has also been added. The required buffers and the use of the least toxic herbicide will minimize the potential impacts of herbicide spraying on aquatic systems.

CO-0115, Paul Hendricks.

Comment No. 1: "We further doubt the wisdom of unleashing a 'Vegetation Treatment' plan in the third year of an extreme drought. If you kill the vegetation and don't reseed you'll surely have a potential dust bowl. Re-vegetating in a drought period is also of questionable wisdom."

Response: Page 1-4 of the DEIS states "Future environmental analyses of vegetation treatment will be conducted at the project level and will focus on resources that are unique to specific sites, as necessary." Site-specific climatic conditions will need to be evaluated to determine both the proper method of vegetation treatment (if any), compliance with mitigation requirements, and to design reclamation (revegetation) plans.

CO-0115.

Comment No. 2: "...detergents kill bees. Beekeepers have observed that surfactants used to dilute herbicides kill bees, especially when sprayed onto water from which bees drink."

Response: Mitigation has been added requiring notification of managed apiaries in the vicinity prior to application of herbicides.

WY-0117, Wally D. Ramsbottom.

Comment: "Insects can be introduced to control undesirable plants."

Response: It is agreed that insects can be introduced as a biological control agent. However, at the present time there are a limited number of insect species that are available as a biological control agent on a limited number of noxious weeds or targeted plant species. See Appendix C2, 3 and 4 for the latest list of biological control agents that have been approved for release in specific states. Also, see the Northwest Area Noxious Weed Control Program (NANWCP) FEIS, 1985 for the list of biological control agents that were available at that time. Biological control agents will be released on specific noxious weeds or targeted plant species as they become available for release. A person must remember that biological control agents are just one of methods of control of weeds in the overall noxious weed management program. It takes a combination of all methods of control in order to have a successful weed management program.

It is agreed that different animals have different foraging preferences of plant species. This is one of the methods of vegetation treatment and noxious weed control that is being proposed in this EIS, such as in Alternatives Numbers 1 thru 4. This was also addressed in the NANWCP FEIS that was approved for use in 1987. Alternative number 1 is the most integrated plant management program of all in the EIS.

AZ-0118, Thomas W. Spalding.

Comment No. 1: "Our department is especially concerned with the possible adverse impacts that application of amitrole, atrazine, bromacil, clopyralid, dicamba, diuron, tebuthiuron, trichlopyr, and 2,4-D would have on terrestrial and aquatic wildlife populations. The monitoring commitment under the proposed action also needs to be very strong, both for the BLM and other agencies using aerial herbicides."

Response: We share your concern of the use of several of the herbicides in important wildlife habitats. We have added some specific mitigation (Chapter 1); including a statement that amitrole and dalapon are no longer proposed for use, and the use of atrazine, clopyralid, diuron, simazine, triclopyr (butoxyethyl ester only), 2,4-D, or diesel oil carriers adjacent to aquatic habitats will be carefully regulated; more discussion of the potential impacts; and a need to monitor the specific impacts of treatments in habitats where little information is available. It is our intent to minimize the unexpected adverse impacts under all treatment methods and alternatives.

AZ-0118.

Comment No. 2: "We question the assessment in the DEIS that the proposed action will have no significant impact on fish, and that adverse impacts to wildlife would be temporary and localized (page 1-27)."

Response: See response to MT-0095, Comment No. 2.

AZ-0118.

Comment No. 3: "Timing recommendations should be considered prior to any hunting season which is scheduled to occur in a treatment area to ensure that hunters do not ingest unmetabolized herbicides."

Response: Mitigation has been added to post areas treated with herbicides to warn hunters about game taken within or near the treated area (Chapter 1), and mentioned again in Chapter 3.

AZ-0118.

Comment No. 4: "The DEIS presents salt cedar as a noxious plant to be eradicated at all costs. Aerial herbicide control of salt cedar could have tremendous adverse impact to a vast array of wildlife species."

Response: We did not clearly state our intentions in treating saltcedar in the draft EIS. Our proposals are for mowing and cutting small areas of saltcedar and treating individual stumps with herbicide applied with a paint brush. There are no proposals to aerially spray saltcedar.

AZ-0118.

Comment No. 5: "The general monitoring guidelines for vegetation treatments (p. 1-25) should be given

much greater emphasis. Monitoring is critical to the determination of whether objectives have been met and the effectiveness of the prescribed treatment."

Response: The section has been revised to reflect this suggestion.

AZ-0118.

Comment No. 6: "Many of the comments are specific to ground-water quality concerns and the lack of information in the DEIS."

Response: See responses to UT-0239, and UT-0104.

AZ-0118.

Comment No. 7: "...there should be some discussion of the cumulative effect of long-term use of herbicides as proposed in Alternative 1."

Response: See Appendix E8-1 for a discussion of bioaccumulation.

AZ-0118.

Comment No. 8: "...timing recommendations should be considered prior to any hunting season which is scheduled to occur in a treatment area to ensure that hunters do not ingest unmetabolized herbicides."

Response: See the revised table E4-1 which now includes Native Americans and would include hunters.

ID-0120, Jay E. Anderson.

Comment No. 1: "A summarization of a contemporary view of vegetation and vegetation dynamics is needed. People need to know what vegetation is (i.e. understand the nature of plant communities) and how it changes in response to climate and disturbance."

Response: Such a discussion has been incorporated into the introduction to the descriptions of the vegetation analysis regions in Chapter 2.

ID-0120.

Comment No. 2: "The document should specifically address the kinds of species and species mixes that will be used in rehabilitation seedings, not to the point of specifying species or mixes, but to provide general guidelines. We seem to have progressed beyond the point of creating vast monocultures of crested wheatgrass in many districts, but managers need to be reminded that such practices are not acceptable."

Response: General guidelines for selecting seeding mixtures have been incorporated into Chapter 1 in the Standard Operating Procedures section.

ID-0120.

Comment No. 3: "The document should specifically address the widespread concern throughout the Great Basin and Snake River country about the loss of native shrub-steppe habitat. Protection of existing stands of sagebrush steppe is of grave concern to managers in Idaho, Utah, and Nevada, and that concern certainly should be reflected in this EIS."

Response: The sagebrush vegetation analysis region description in Chapter 2 has been revised to incorporate this concern.

ID-0120.

Comment No. 4: "I fail to see how Alternative 2 would result in 'less improvement on species diversity.' Widespread application of herbicides will almost certainly result in a decrease in species richness."

Response: This conclusion is based on results achieved by the end of the time period covered by the EIS, as opposed to results in the near term after treatment, and reflects both less treated acreage in Alternative 2 and certain opportunities foregone, such as treatments which help restore perennial vegetation to cheatgrass areas.

DC-0123, Richard E. Sanderson.

Comment No. 1: "While most of the important environmental consequences of the program have been addressed in the DEIS, EPA believes that the final document should more fully describe how site-specific environmental assessments will be made and should include more information on the pesticides proposed for use in the program."

Response: Site-specific analysis will be prepared at field levels (usually Resource Area and/or District Offices) in conformance with BLM NEPA Policy Handbook (H-1790-1) which describes standard format and structure to comply with all federal guidelines for NEPA compliance. See revision to Chapter 1 dealing with this subject. Information on how herbicides will be used is provided in Chapter 1, i.e., text changes in Weed Management Treatment (BLM Manual 9011) and Design Features.

DC-0123.

Comment No. 2: "To better describe the environmental impacts of the program, the FEIS should also include more detail on the environmental fate and transport of the 19 herbicides proposed for use in the program."

Response: The text in Chapters 1 and 3 have been revised.

DC-0123.

Comment No. 3: "Clarification of information concerning pesticide use and correction of factual deficiences should be included in the FEIS. Our attached detailed comments address these two areas."

Response: BLM has reexamined the risk assessment and examined additional data for amitrole, and has determined that amitrole is no longer considered for proposed use in this document. Amitrole will be deleted in the Record of Decision. Since drafting this document, producers are no longer manufacturing dalapon formulations registered for proposed use. Therefore, dalapon is no longer considered for use. The simazine summary in Chapter 1 has been revised. See Chapter 3 and Appendix E revisions.

DC-0123.

Comment No. 4: "Factual deficiencies concerning various herbicides are provided in detail."

Response: The text in Chapter 3 and Appendix E5 has been revised, in particular regarding changes resulting in risk assessment for atrazine and simazine as discussed further below.

DC-0123.

Comment No. 5: "The DEIS reports that exposure to the carriers in herbicide formulations is highly toxic to bird eggs without mentioning what mitigating steps are available to minimize this hazard."

Response: Mitigation has been added to protect bird eggs during the nesting season (Chapter 1).

DC-0123.

Comment No. 6: "Table E4-9, maximum application rate for simazine is 10 pounds active ingredient per acre."

Response: Table E4-9 has been changed to reflect 10 pounds for simazine used on oil and gas sites and on rights-of-way. The Appendix E5 text has been revised in many places to reflect the new margin of safety (MOS) for simazine at these sites.

DC-0123.

Comment No. 7: "Page E3-38 of the DEIS, atrazine NOEL should be changed from 15 ppm to 150 ppm for systemic."

Response: The statement "and is the systemic NOEL used in this risk assessment" has been deleted from the text. The following statement has been added to the text: "A more recent 1-year dog study where animals were fed dietary levels up to 1,000 ppm, a NOEL of 150 ppm (5 mg/kg/day) was reported based on cardiac effects. Therefore, the systemic NOEL used in this risk assessment is 150 ppm (EPA 1989)."

DC-0123.

Comment No. 8: "Page E3-40, concerns atrazine data gaps."

Response: The text has been revised to read, "EPA will soon issue a data call-in letter identifying a number of data gaps, among them mutagenicity assays." Numerous tables in Chapter 3 as well as Appendix E5 have also been revised to reflect changes. Figure 3-4 was changed to show 5 mg/kg/day for atrazine.

DC-0123.

Comment No. 9: "The Aquatic Exposure Estimate section should use a 6-inch pond depth exposure level to determine environmental concentrations."

Response: The consensus was that a 1-foot pond would be the best representative depth and therefore, the text has been modified. See Appendix E7 and E8 changes.

ID-0126, Jerry M. Conley.

Comment No. 1: "Primary and secondary effects of herbicides on the large majority of wildlife species are inadequately known, but we **do** know that such secondary effects as loss of sagebrush due to herbicide treatment can be detrimental to such sagebrush-dependent species as sage grouse and pronghorn antelope."

Response: The potential impacts to sage grouse and other wildlife from removal of sagebrush had been addressed in the draft, but has been strengthened and further mitigated in the final EIS (Chapter 1).

ID-0126.

Comment No. 2: "The EIS does not mention the obvious treatment of reduction or elimination of livestock grazing which would allow seral development that will control undesirable plant species."

Response: While it is true a stable climax or disclimax plant community would have significantly reduced frequencies of many undesirable species, once many of these plants are introduced their highly competitive nature soon replaces the native climax plants. While grazing does not occur in many highway rights-of-ways or railroad rights-of-ways, these areas have some of the more significant noxious weed problems simply due to the competitive nature of the weedy species.

The encroachment of pinyon Juniper into native sagebrush range can occur regardless of grazing and eventually develops into a closed canopy crowding out all understory vegetation. Unless wildfire or prescribed burning occurs, mechanical treatment is necessary if big game habitat is to be maintained. Many of the state agencies responsible for wildlife management, have participated in land treatments, in cooperation with BLM, for the benefit of wildlife.

ID-0126.

Comment No. 3: "A stable climax or disclimax plant community would have significantly reduced frequencies of many such species [like death camas or larkspur]; one reason they are common on many ranges now is that livestock won't eat them and, if the goal of BLM management was not solely designed to increase livestock forage, control would not be necessary."

Response: Even with good animal husbandry, livestock losses occur from localized proliferation of these plants in specific locations. In areas where losses continue and livestock use is a legitimate use of those areas under the land use plan, treatments may be proposed to speed the rehabilitation process and decrease animal losses. Treatment is a short-term solution that must be combined with good grazing management to achieve reduced frequencies of these species in the long-term.

ID-0126.

Comment No. 4: "The section relating to the effects of herbicides on aquatic systems in the DEIS is totally inadequate; specified water quality standards must be addressed in the DEIS."

Response: See responses to UT-0239, and UT-0104.

NV-0129, John B. Walker.

Comment: "Attached is an updated sensitive species list for your use."

Response: The most up-to-date information on listed and candidate species according to Fish and Wildlife Service was used for Appendix H.

UT-0130, Jerry Schmidt.

Comment: "Removing trees from the land hurts the Earth's ability to remove carbon from our atmosphere and contributes to the greenhouse effect, and I believe the BLM and all other land management agencies should be made to consider this factor in their decisions with regard to environmental analysis."

Response: All vegetation is important in the processing and recycling of oxygen and carbon through photosynthesis. By converting carbon dioxide into oxygen and plant fiber, carbon is "fixed;" removed from the atmosphere until the plant material either decomposes or burns. Global carbon dioxide and methane levels are increasing, and have been called "greenhouse gases," implying their increased concentrations may lead to global climate change. Although the "greenhouse effect" theory is very popular, the probability of its occurrence is unknown at this time. To validate the theory, a multi-year, multi-million dollar research program was established by President Bush, and is administered by the interagency Committee on Earth Sciences. The Bureau of Land Management is a participating agency in this research.

Although grassland may fix carbon at a faster rate than a pinyon/juniper forest, the total mass of fixed carbon is much less (nearly one tenth.) One acre of pinyon/juniper forest (assuming 5 tons/acre of cellulose - $C6H10O5$) consists of nearly 2.2 tons fixed carbon, which if burned completely, would form 8 tons of carbon dioxide. This is comparable to burning 880 gallons of gasoline (represented as 6 pounds per gallon heptane - $C7H16$). World-wide carbon dioxide emissions (1990) are estimated to be nearly 28 billion tons per year (Stern, A. C. 1976. Air Pollution: Third Edition, Volume 1 - Air Pollutants, Their Transformation and Transport. New York: Academic Press).

UT-0139, James Wheeler.

Comment No. 1: "Page 6 of the executive summary contains a reference to poisonous plants involved with recreation and visual resources. What plant species harmful to people are to be controlled? Death

Camas is a naturally occurring species that should not be eliminated just because it is harmful to people. Plants poisonous to livestock should not be a problem in recreation areas for people."

Response: As discussed on page 3-59 of the DEIS, certain plants can be harmful to people and may be controlled on certain sites, such as campgrounds and trails, where there is high probability that visitors will be exposed to injury or illness from thorns, burrs, skin irritants, or poisonous plants. Examples of species which might be controlled for these reasons include Canada thistle, Mexican cocklebur, puncture vine, poison ivy, and poison hemlock. Death camas is not normally a problem to recreationists, but poison hemlock can be deadly.

UT-0139.

Comment No. 2: "Cultural resources need to be addressed in project specific environmental analyses."

Response: See response to WY-0085.

OR-0163, J-M Michelsen.

Comment No. 1: "With the increasing aridity of the Southwest, this is not the time to be disturbing vegetation."

Response: See response to CO-0115, Comment No. 1.

OR-0163.

Comment No. 2: "The DEIS also needs to pay more attention to the legislative mandates in the Clean Air and Clean [Water] Acts. There are a [number] of specifically and strictly protected areas within the 13 states covered by the DEIS and these need to be addressed."

Response: The Bureau clearly intends to comply with these air quality regulations, including designated Prevention of Significant Deterioration Class I and nonattainment areas (as described on Pages 2-21 through 2-25 in the DEIS). The Bureau has a long history of cooperating with the National Park Service and the U.S. Environmental Protection Agency concerning air resource management. The Bureau also actively participates on the Western States Air Resource Council, an association of state air regulatory agencies and Federal land management agencies.

UT-0176, Owen Severance.

Comment No. 1: "The draft EIS also does not address the release of CO_2 and its contribution to global warming that will occur from burning hundreds of thousands of acres of mature pinyon/juniper."

Response: See response to UT-0130.

UT-0176

Comment No. 2: "The EIS should also require new VRM data for each project since recreational use of BLM land is rapidly increasing along with the public's concern about visual quality."

Response: If Visual Resource Management (VRM) site specific project data is outdated, inadequate, or nonexistent, a BLM manager may order an updated or new VRM inventory prior to preparation of the Visual Contrast Rating for the particular project.

UT-0176 Comment No. 3: "Cultural resources need to be addressed in project specific environmental analyses."

Response: See response to WY-0085.

AZ-0182, Stephen M. Williams.

Comment: "On page 1-1 and 1-6 Appendix I, Target Plant Species, is misidentified as Appendix H. Appendix H is Special Status Species list."

Response: Correction has been made.

ID-0187, Glen W. Shewmaker.

Comment: "Concerning oral LD_{50} in rats (figure 3-3; it would be good to compare common household toxicants on the same chart, eg: table salt, alcohol, gasoline, chlorox, cigarette smoke, aspirin, vitamin supplements."

Response: A risk of death comparison is on page E5-4 of the DEIS. Since the health risks for the BLM program are based on more factors than LD_{50}, the value of a chart as suggested is not apparent.

NV-0197, William A. Molini.

Comment No. 1: "Evidence suggests and we believe that a major factor in the long term decline of sage

grouse in the west has been caused by vegetal treatments."

Response: The discussion of potential impacts of treatment of sagebrush on sage grouse has been revised in the final. Mitigation has been added (Chapter 1) and the discussion in the Impacts analysis (Chapter 3) have been expanded.

NV-0197.

Comment No. 2: "It would be interesting to know just how many of the 372,000 acres proposed to be treated annually are actually targeted to benefit commodity land uses."

Response: Almost all of the 372,000 acres of proposed treatment will directly or indirectly benefit commodity land uses through reduction or elimination of noxious weeds, increases in forage quantity and quality, improved water quality and reduction of fire hazards. Likewise, mitigation will normally benefit big game animals through improved forage diversity.

NV-0197.

Comment No. 3: Sagebrush also serves as important thermal cover for big game species. In areas of limited rainfall and forage production the thermal cover provided by sagebrush may be critical to deer survival.

Response: The stated concern has been addressed in the Final EIS in Chapters 2 and 3.

NV-0197.

Comment No. 4: "The discussion of mechanical methods of treatment for the sagebrush type tends to understate the damage to desirable shrubs. Our observation has been that desirable shrubs are nearly always severely damaged or eliminated by plowing."

Response: Degree of impact on desired plant species will be evaluated in site specific analyses to insure adequate protection for key species affected by treatment. In cases where only partial eradication of a shrub is desired, options in treatment design can be planned to achieve desired effects.

AZ-0203, Dennis W. Sundie.

Comment: "Patterns identified in the legend for the Columbia Lava Plateau and Glaciated Central Region are reversed from that depicted in the map. (Figure 2-7, page 2-32.)"

Response: Figure 2-7 has been corrected.

MT-0205, James Phelps.

Comment No. 1: "Nothing affects species diversity like vegetative manipulation. Are there any studies showing the results of this? Are there studies that show species diversity is increased by vegetative manipulation? In our experience, such actions tend towards monocultures, or at least in the direction away from species diversity."

Response: The effects of vegetation treatment on diversity of the treatment site depends on many different factors, including kind of site, site conditions and diversity prior to treatment, how soon after treatment a treatment applied, and when and how treatment is applied. Creation of a monoculture of any kind is not a viable treatment objective, and the best technical knowledge we have goes into treatment design to avoid such a result. We cannot categorically address the effects of vegetation treatment on species diversity. Ecological responses and principles are discussed for all treatment methods in Chapter 3, Part 1 of the DEIS in relation to vegetation (pages 3-5 through 3-29) and relation to fish and wildlife on pages 3-46 through 3-58. As the discussions reveal, some things are enhanced by treatment, others are not. In general, some variety of species and plant lifeforms will most likely be the treatment objective for multiple-uses on a site proposed for treatment, and practices which do not essentially maintain or enhance pre-treatment diversity are not likely to meet multiple-use objectives. Treatment effects on diversity are also discussed earlier in this chapter in Common Concerns and Responses (page 4-12).

MT-0208, Phil Johnson.

Comment No. 1: "The BLM is advised to check with the appropriate state pesticide-licensing agency to be assured that herbicides intended for use in a particular state are indeed registered for that year. The BLM should also be cognizant of the labeling restrictions dealing with "non-cropland," "rangeland" and "pastureland." Each are unique terms with regard to labeled application sites."

Response: The BLM is aware that pesticide registration and labeling restrictions can vary between individual states. During the site specific analysis and preliminary planning of weed management programs pesticide registration and current labeling restrictions will be checked to ensure that only approved herbicides will be used and no label res-

trictions will be violated. Refer to the Standard Operating Procedures section of Chapter 1.

MT-0208.

Comment No. 2: "The discussion on the use of grazing animals as an effective biological control measure should be expanded."

Response: See revised text, Chapter 1, Biological section on the use of grazing animals as an effective biological control measure.

When considering the use of grazing animals as an effective biological control measure the following factors are taken into consideration: target plant species present, other plant species present, stage of growth of both target and other plant species, palatability of all plant species present, selectivity of all plant species present, type of management program that is logical and realistic for the specific treatment site, grazing animal species that is being considered and the availability of that grazing animal within the treatment site area. These factors will be some of the options taken when developing the individual treatment for a specific site.

The discussion of past land management practices has been addressed in Grazing Allotment Management Plans, and Resource Management Plans.

DC-0210, James W. Stewart.

Comment: "The Clean Air Act Section 169A and subsequent Environmental Protection Agency regulatory requirements should be discussed, particularly because of their significance regarding Class I areas, the vast majority of which are located in those 13 Western States. Coordination with adjacent National Park Service (NPS) units where visibility is an important value, especially during periods of high visitation, should be discussed in the final EIS."

Response: See response to OR-0163, Comment No. 2.

UT-0218, Ted Lee.

Comment: "Biological control of weeds can be done by using pathogens, insects, and livestock. More emphasis needs to be placed on these control methods."

Response: Please refer to responses to letters WY-0117, and MT-208, Comment No. 2.

NM-0226, Roger S. Peterson.

Comment: "We object to the EIS's use of 'infesting' in connection with this [sand shinnery] oak on p. 3-109."

Response: Text has been revised.

CO-0227, Roger Flynn.

Comment No. 1: "Objective of the EIS involves human manipulation of the environment as opposed to keeping the land in its "natural condition" which we hardly find as consistent with the intent of FLPMA."

Response: The Federal Land Management and Policy Act does not mandate that all lands be managed in a natural condition. Section 102 of the act states "the public lands be managed in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air, and atmospheric, water resources, and archaeological values; that where appropriate, will provide food and habitat for fish and wildlife and domestic animals; and that will provide for outdoor recreation and human occupancy and use." Letting nature take its own course does not always provide the desired plant community. Many introduced noxious weeds, even though non-poisonous, are very competitive in nature and crowd out desired vegetation.

CO-0227.

Comment No. 2: "Again, we find conflict with the goals of FLPMA and the BLM's actions. The DEIS does not include a "complete and current" inventory of all sensitive, threatened, rare and endangered species located within the scope of this project."

Response: Proposed treatments in this document are also covered within Land Use Plans and supporting documentation; also site-specific analyses will be prepared on projects. These two documents will more specifically address the threatened, endangered, and candidate species occurring within the proposed treatment areas. Prior to implementation of any of these proposed treatments, an analysis of impacts to all special status species will occur within the two levels of the more specific environmental analysis documents mentioned above.

CO-0227.

Comment No. 3: "What is the chance that each [special status] species will be subject to each of the var-

ious vegetative treatments (mechanical, chemical, etc.)? And what are the effects of all the treatments on all of the special status plants?"

Response: Chapter 3 impact discussion has been revised to clarify the level of impact to special status species.

CO-0227.

Comment No. 4: "The goal to 'create stratified age structure dynamics in rangeland' (DEIS 1-6), will probably not be met by interrupting ecological succession."

Response: Prescribed fire is sometimes used in mature or decadent oak or chaparral shrublands to consume older material and stimulate new growth that is more accessible to wildlife. Such treatments create multi-aged mosaics and better resemble conditions under natural fire regimes. In forest or woodland types it is also possible to selectively treat stands or individuals to achieve an uneven-aged situation. Any treatment that opens an even-aged stand and provides an opportunity for a pulse of regeneration can eventually create stratified age structure in a variety of vegetation communities.

CO-0227.

Comment No. 5: "The DEIS makes no mention of the parasitic relationship of Castilleja to other organisms. What effect will this have on its parasitic partners?"

Response: The effect of herbicides on "parasitic partners" will vary depending on their susceptibility to the specific herbicide. During the site specific evaluation non-target species, whether they are "parasitic partner" or not, will be considered as to the method of control. If the use of an herbicide is selected as a method of control, the specific herbicide selected will depend upon the susceptibility of both the target and nontarget plants present.

CO-0227.

Comment No. 6: "In light of all the recent discoveries about the rate at which old growth vegetation is being systematically removed, it is with great alarm that we note the BLM's failure to consider this aspect of pinyon-juniper and creosote communities."

Response: The potential value of retaining old growth pinyon-juniper forests as wildlife habitats has been described in Chapter 2, and considered in Chapter 3 in the impact analysis discussions of the final EIS.

CO-0227.

Comment No. 7: "We assert that the "wildlife" increase will be largely game species. We do not consider game ungulates to be an adequate indicator of the overall health of wildlife."

Response: As discussed in response to NM-0038, all wildlife species will be considered during the site-specific analysis level.

CO-0227.

Comment No. 8: "The preferred alternative calls for intensive chemical treatment and therefore is not a plan for increasing wildlife habitat in the pinyon-juniper zones in contradiction to DEIS page 3-56."

Response: The evaluation process on individual treatments includes the consideration of the site-specific resources and a balancing of resource allocations that will occur as a result of the treatment. Multiple-use management is in essence the management of allocations, as nothing is done without some affect on the balance of the biotic community. The application of vegetation treatments acknowledges the use allocation philosophy and as indicated in the above response, the end product is judged to be more beneficial than the losses from the previous community.

CO-0227.

Comment No. 9: "The DEIS fails to adequately discuss the effect this treatment will have on the endangered peregrine falcons that inhabit the canyonlands of southern Utah."

Response: The primary prey species for the Canyonlands population of peregrine falcons should be the riparian and aquatic related avian species, and the cliff related swallow and swift populations. The mitigation added in Chapter 1 add further protection to riparian and aquatic habitats, and nesting birds, reducing the potential for significant adverse impacts. More specific potential impacts will be addressed in the site-specific environmental analyses.

CO-0227.

Comment No. 10: "The first basic inadequacy of this programmatic DEIS involves its overbroad lack of specificity which avoids the close scrutiny necessary when evaluating the environmental impacts of program implementation in specific areas."

Response: This EIS meets requirements under FLPMA and NEPA. Please see section in Chapter 1 entitled, Legal Mandates for the Program and NEPA Requirements of the Program. In addition, responses to concerns expressed on cumulative analysis and alternatives were provided in the general issues earlier in this chapter.

ID-0229.

Al E. Murrey.

Comment No. 1: "The DEIS does not fully address impacts of biological methods of vegetation manipulation to water quality. Grazing of cattle and sheep is a major method of biological manipulation..."

Response: See response to UT-0239.

ID-0229.

Comment No. 2: "Many of the comments are specific to ground-water quality concerns and the lack of information in the DEIS."

Response: See responses to UT-0239, and UT-0104.

ID-0230, Janet O'Crowley.

Comment No. 1: "Exec-5, 'Fish and wildlife:' The statement "Fishery resources are not likely to be significantly impacted under any of the treatment methods or alternatives" is inaccurate and inadequate in light of the fact that most of the herbicides proposed for use are toxic to macroinvertebrates (the primary food source for fish), fish, and other aquatic organisms."

Response: Exec-5, Fish and Wildlife has been rewritten to more clearly summarize the expected impacts, also see response to NM-0038, and Mitigation in Chapter 1.

ID-0230.

Comment No. 2: "Overall, alternative 1 would not necessarily have the most beneficial impact on wildlife especially in light of the proposed 4-fold increase in herbicide use on the public lands."

Response: Portions of the impacts to wildlife for Alternative 1 have been rewritten to reflect potential adverse impacts or to better clarify why the expected impacts could occur. (Also, see response to NM-0078.)

ID-0230.

Comment No. 3: "Page 3-10, Sagebrush: No discussion is provided describing how desired vegetative results would be achieved after mechanical treatment is complete."

Response: The summary of the Sagebrush section has been revised to clarify how desired vegetative results are achieved on sagebrush sites.

ID-0230.

Comment No. 4: "Aren't most of the herbicides proposed for use either carcinogenic or toxic to birds, mammals and macro-invertebrates?"

Response: Seven of the 19 herbicides are being assessed as if they were carcinogenic. These are amitrole, atrazine, bromacil, 2,4-D, glyphosate, picloram and simazine. BLM has reexamined the risk assessment and examined additional data on amitrole. BLM has determined that amitrole is no longer considered for proposed use in this document. Amitrole will be deleted in the Record of Decision. See Table E6-1 for a summary of acute toxicity to rats and mallards, and Tables E8-1 to E8-22 for a risk comparison of estimated wildlife doses from the various herbicides to toxicity references levels. It is acknowledged on page E8-3 of the Draft EIS (DEIS) that "local populations of small mammals, small birds, terrestrial amphibians, and reptiles may be adversely affected if large areas are treated.

ID-0230.

Comment No. 5: "What is the impact on insects and other natural pollinators?"

Response: Statements concerning the toxicity to bees and other insects are found on pages E6-1 to E6-13 of the DEIS as part of the Wildlife Hazard Analysis. There is no summary. Criteria for rating the risk assessment is found on page E6-1.

NM-0232, George Grossman.

Comment No. 1: Expressed concerns as to alternatives provided, rationale, and alteration of natural ecosystems.

Response: Please see revision for added emphasis of purpose and need section (Chapter 1), and Vegetation section in Chapter 2. Also see responses to UT-0079, ID-0120, MT-0205, UT-0253, and UT-0265.

NM-0232.

Comment No. 2: "Alternatives No. 1 and No. 5 include aerial spraying of herbicides. Especially with fixed-wing aircraft, this method tends to produce the large brush-free areas (rather than smaller-scale mosaics) that are worst for wildlife habitat."

Response: Statements have been added to the discussions of Alternatives 1, 2, and 4 indicating that aerial application of herbicides can cause significant adverse impacts to wildlife, and mitigation have been added to protect wildlife from some impacts from aerial application of herbicides.

NM-0232.

Comment No. 3: "Where applicable, we feel that fire is the best treatment method available for invasive shrubs and noxious weeds. It is often suitable to rangeland invaded by mesquite; it usually allows a few older trees to survive, as they should for the sake of wildlife."

Response: Statements have been added to the discussion of Alternative 4 expressing similar concerns on behalf of the wildlife resource, and pointing out that this alternative also has the largest number of acres of aerial and total herbicide application.

NM-0232.

Comment No. 4: "In any case, we oppose the use of herbicides that are (1) nonspecific or (2) long-lasting in the soil..." This comment indicates some concern for possible ground water contamination.

Response: See response to UT-0239.

NM-0232.

Comment No. 5: "Why does BLM plan to use tebuthiuron which is toxic to mammals and has no place on public lands?"

Response: See response to ID-0230, and Table E8-18.

OR-0233, Jan Wroncy.

Comment No. 1: "The Draft EIS does not consider obtaining informed consent from the members of the public who are assumed to be likely to receive some amount of exposure from pesticides, by-products, contaminants, pyrolytic or phytolytic products, petroleum distillates, inerts, surfactants, smoke, fire ignitors and/or fire retardants that may be used in the vegetative management program."

"The Bureau of Land Management may be unaware of how much pesticides drift, leach, vaporize, generally move about, and persist, but the BLM certainly can not deny that the smoke (and any additional chemicals in it) created by the intentionally set fires on BLM lands does not travel off the site to other properties not belonging to the BLM. The members of the public, individually, need to be asked whether they will give their informed consent to such exposure and to the trespass onto their land."

Response: The DEIS states on Page 1-30 (State and Local Governments) "The act [FLPMA] also requires BLM to provide for compliance with applicable pollution control laws, including State and Federal air and water pollution standards or implementation plans." On Page 3-30 (Impacts on Air Quality), the DEIS states "Federal, State, and local air quality regulations would not be violated." The Bureau is subject to the same air pollution regulations as other federal agencies, industry, and private citizens. This does not include obtaining "individual...informed consent" of the public, but compliance with the laws created and enforced by elected and appointed officials representing the public.

OR-0233.

Comment No. 2: "First of all there is not complete information given as to the full formulations of the pesticides, what their inerts are, what their breakdown products are, their pyrolytic or phytolytic products, what surfactants, spreader-stickers, activators or contaminants are in them, much less any health, environmental fate or impact information about them."

Response: See the DEIS page 1-31 for a discussion of the limitations of this document. The last paragraph reads, "The human health and nontarget species herbicide risk assessment was based on the most recent available information concerning herbicide toxicity and environmental fate properties." Also see response to OR-0238.

OR-0233.

Comment No. 3: "It is increasingly recognized by the medical community that there are a rapidly growing number of chemically and smoke sensitive people."

Response: Please see Appendix E5-19 and 20 for Factors Affecting the Sensitivity of Individuals and Likelihood of Effects in Sensitive Individuals.

CO-0235, Julius Dahne.

Comment No. 1: "The DEIS is flawed because it relies upon outdated methods to determine the persistence of herbicides in the soil."

Response: Please see the last paragraphs on each chemical in Chapter 1, and text revisions on this topic in Chapter 3 impact section in the final EIS.

CO-0235.

Comment No. 2: "However, there is no analysis of the risks posed by noxious weeds to balance the risks to human health against."

Response: See revised text in Chapter 1 for discussion of purpose and need and program objectives.

CO-0235.

Comment No. 3: "...under typical conditions of rangeland treatments, and under typical conditions of public-domain forest land herbicide applications, 'members of the public may be at risk of systemic effects and an increased cancer risk from amitrole.'"

Response: BLM has reexamined the risk assessment and examined additional data. BLM has determined that amitrole is no longer considered for proposed use in this document. Amitrole will be deleted in the Record of Decision.

CO-0237, Angela Medbery.

Comment No. 1: "I would expect to find different options applied successively on the same land for optimal management and expected to see some of those combinations discussed in the management plan. They were not in the DEIS."

Response: In regards to options for optimal management and management plans, these considerations are provided in Resource Management Plans, not in this EIS (see responses to common issues earlier in this chapter on this subject).

CO-0237.

Comment No. 2: "Is there a particular density of a particular plant species in a specified use area that will trigger the need for a management plan to be implemented?"

Response: Yes, density of target plant species and a number of other factors are considered prior to treatment. See text which has been revised to clarify this point in Chapter 1, Standard Operating Procedures section.

CO-0237.

Comment No. 3: "Inert ingredients and surfactants can also cause various health related impacts."

Response: See response to OR-0238, Comment No. 9.

CO-0237.

Comment No. 4: "One study...found leukenia risk in children 6.5 times greater if the parents used pesticides in the home and on the yard. How do BLM use risks further impact these kids?"

Response: See Appendix E5-18 for Synergistic Effects and E5-20 for Factors Affecting the Sensitivity of Individuals.

CO-0237.

Comment No. 5: "Some people are very sensitive to pesticides and other chemicals."

Response: See Appendix E5-19 to 21 for Effects on Sensitive Individuals.

OR-0238, Norma Grier.

Comment No. 1: "The DEIS does not address the causes and prevention of vegetation problems. The EIS never considers why the land and the vegetation is the condition it is...The least BLM needs to do is spell out where the causes of vegetation problems are addressed in BLM documents."

Response: The text has been revised in the Final EIS regarding historic vegetation conditions and factors that have contributed to present conditions in Chapter 2, Analysis Region Descriptions, Vegetation. Also, these factors are considered prior to treatment, and objectives and design developed in accordance with allotment management plans (AMPs)and resource management plans (RMPs). RMPs provide a categorization of all rangelands considered, based on present and past conditions.

OR-0238.

Comment No. 2: "The document ignores concerns with groundwater contamination..." The letter

offered several comments related to ground water, water quality, and drinking water standards.

Response: We agree. We have added additional emphasis to the use of ground water as a drinking water supply. See text for revised section. See response to UT-0239.

Two documents are useful for evaluating the potential of forestry pesticides to reach ground water. "Pesticides in Groundwater of the United States of America" was a survey of state lead agencies, prepared as part of NAPIAP, by the Oregon State University Extension Service. The 1988 update of the California Well Inventory Data Base includes some 40,000 samplings for Sept. 1, 1987 to June 30, 1988. Both represent primarily agricultural uses because of the high local frequency of use in agriculture and the very small fraction of total use ascribable to rangeland, even in the Northwest. Therefore, findings as a result of agricultural use are more likely than would be the case following rangeland uses. In addition, agricultural uses are continuous, so that when used in an area that is a potential conduit to ground water, the "pipeline" concentration in the conduit is maintained. Intermittent or infrequent use as characterized by rangeland uses will permit dissipation before the material reaches an unacceptable location.

Ground water sampling is not usually done in a random manner. The great costs of analysis dictate that sampling will be directed; samples are usually taken only where there is reason to expect appearance of a pesticide in a water source. This means that surveys will be biased toward positive findings. Given the intensive character of agriculture, it is remarkable that so few detections are seen, and that so few of those approach an action level.

For the herbicides discussed in the comment, the OSU survey of state lead agencies responsible for water quality shows the following:

Herbicide	Number of Wells	ND	Less than ppb	Less than HA	Greater than HA
atrazine	5568	4798	17	743	11
bromacil	726	720	—	6	—
dalapon	14	14		(only one state analyzed)	
dicamba	1239	1196	5	38	—
diuron	998	976	—	22	—
hexazinone	198	197	—	1	—
picloram	1028	990	10	28	—
simazine	2922	2819	3	99	1
tebuthiuron	31	31		(only one state analyzed)	

ND = not detected

HA = EPA Health Advisory level

Imazapyr was not listed. It is relatively recent herbicide, with low application rates.

The California Well Inventory indicates a similar pattern. In this program wells with positive findings are often resampled for confirmation. The following data are presented as numbers of wells sampled and numbers positive. The report also indicates numbers of counties sampled against counties with positive findings. These latter data are not shown here.

Herbicide	Number of Wells	Number of Negative	Number of Positive
atrazine	319	317	2
bromacil	186	186	0
dalapon	2	2	0
dicamba	55	55	0
diuron	323	23	0
hexazinone	no sampling during this period		
picloram	no sampling during this period		
simazine	325	324	1
tebuthiuron	no sampling during this period		

It seems highly unlikely that any rangeland use of herbicides represents a threat to ground water. This does not negate the need to pay close attention to use practices to assure protection of water sources.

OR-0238.

Comment No. 3: "No public agency should undertake programs that have any potential for contaminating groundwater..."

Response: See response to UT-0104.

OR-0238.

Comment No. 4: "BLM has assumed that picloram is carcinogenic for the EIS analysis."

Response: BLM is purposely being highly conservative in assuming carcinogenicity of picloram. Conservatism is not out of place, but needs to be placed in context. The study by NCI from which the argument stems found benign liver nodules in female rats only, after a lifetime exposure to time-weighted average dietary concentrations of picloram of nearly 15,000 ppm. This translates to an average daily dose rate of about 750 mg/kg/day. The panel of NCI experts who evaluated the data identified picloram as a chemical for which evidence of carcinogenicity was at best equivocal. This finding was disputed by another pathologist acting independently, who stated that picloram was indeed a potent carcinogen. His opinion triggered a further evaluation, which agreed with the original assessment.

It is customary to assume for purposes of risk assessment that even equivocal data does represent a real effect. It is entirely proper, philosophical arguments by the respondent notwithstanding, to conduct a quantitative risk assessment on the basis of animal carcinogenesis data, whether definitive or equivocal. Such analyses are biased to conservatism and provide some sense of the upper level of risk that might be incurred by an exposed person. Other factors must be considered as well. The principal exposed population is occupational, for whom contact can be well controlled. Furthermore, skin absorption of picloram is lower than that of almost any other chemical, a fraction of one percent. The nature of picloram use in vegetation management is such that exposure of the general public through environmental routes following rangeland use is minimal to non-existent. The potential of herbicides as a class, including picloram, to reach ground water as a result of actual use has been addressed above. The theoretical consideration of picloram as a carcinogen is a starting point from which to then incorporate all of the real world factors that can influence impact, and such an examination does not indicate any reasonable probability of cancer risk.

OR-0238.

Comment No. 5: "A quantitative human health risk assessment if morally repugnant and inappropriate as a decision making device or BLM."

Response: The option of using a quantitative risk assessment (QRA) in judging probability that a given exposure will result in adverse effect, particularly cancer, appears to be accompanied by two other options. Either a threshold based assessment can be used, as most other countries do, or it can be assumed that any amount of a chemical that is even equivocally active will cause cancer. While a threshold based approach is almost certainly correct biologically for many carcinogens, it is not yet sufficiently established as a regulatory device. The second option is self-evidently flawed, because no chemical can be proven non-carcinogenic.

QRA is not a perfect system and will never be, but where human epidemiology and estimates from animal carcinogenicity assays can be compared, the two are not inconsistent. It is generally agreed that QRA overestimates cancer risk, which is appropriate. It is also widely conceded that the arbitrary hypothetical risk level of 1 x 10E-6 deemed to be acceptable by regulatory agencies, is indeed virtually equivalent to zero.

Given that zero risk cannot be achieved in any context, and that zero risk demanded of any action that affects others logically demands zero risk of ALL actions that affect others, such a standard as one hypothetical case in a million lifetimes seems reasonable. There is no difference in principle between using a chemical that carries some finite probability of health effect, and using a wood stove. A stove is one of several alternatives for heating space, and even the best designs produce an array of carcinogens of high potency as well as other toxic materials that are distributed widely, imposing significant estimated risks on the surrounding community, as well as clinically observable disease. A large fraction of all risks are imposed by others, because even voluntary actions that carry risk are involuntary if any risk-bearing component of the action is not perfectly understood for the purpose of informed decision.

The idea of a "one in a million" cancer risk quite naturally brings forth the question, "what if I am the one?." The same question comes forth when discussing the idea that one molecule of a carcinogen will cause cancer. Those odds are on the order of one chance in 100 billion billion lifetimes, and the question is as valid in either case. Also, in either case, it is not possible to show that such a level truly represents a point below which risk does not exist.

OR-0238.

Comment No. 6: "2,4-D would be used only as a last resort because of epidemiological evidence that phenoxy herbicides cause lung cancer, stomach cancer, Hodgkin's disease, non-Hodgkin's lymphoma, and soft tissue sarcoma in humans."

Response: With respect to the assertion that 2,4-D is a carcinogen, it is incorrect to state that there is epidemiological evidence that phenoxy herbicides cause "lung cancer, stomach cancer, Hodgkin's Disease, non-Hodgkin's lymphoma and soft tissue sarcoma in humans." Aside from the epidemiological evidence that no relation exists, which is no more reliable than that showing association, the data have been recently examined by two panels of scientists,

one organized by the Canadian Center for Toxicology, the other by the Harvard School of Public Health. In the former case there was found to be "insufficient evidence to conclude that 2,4-D is a carcinogen or that existing uses of 2,4-D in Ontario pose a significant health risk." The Harvard panel, half of whom were nationally recognized epidemiologists, concluded that "While a cause-effect relationship is far from being established, the epidemiological evidence for an association between 2,4-D and non-Hodgkins lymphoma is suggestive and requires further investigation. There is very little evidence of an association between use of 2,4-D and soft tissue sarcoma or Hodgkins disease, and no evidence of an association between 2,4-D use and any other form of cancer."

OR-0238.

Comment No. 7: "This cancer concern was in addition to demonstrated neurotoxicity in humans and developmental and reproductive toxicity in animals."

Response: A further statement on page 6 speaks to the "demonstrated neurotoxicity in humans and developmental and reproductive toxicity in animals." The neurotoxicity of 2,4-D is discussed in the Region 6 EIS on page 3-55,56. The cases discussed are each in individuals who were exposed to significant amounts of concentrated material either by dermal contact or ingestion. (There are several other cases in the literature, including suicide attempts, that for some reason were not included in the EIS.) These cases extend back three decades. Many such heavy exposures resulted in no evidence of neural effect. No cases have been reported in the literature of such responses in exposures to dilute material. Efforts to show such effects in animals have not been successful, as the Region 6 EIS states.

Developmental and reproductive toxicity of 2,4-D in animals has been well known since the fifties. Most chemicals will produce these classes of effects in the laboratory, if the health of the mother is not impaired first. 2,4-D is not particularly potent as a teratogen, fetal intoxicant or reproductive toxicant. The critical point is that such responses are dose dependent and demonstrate thresholds of effect, and the margins of safety are high. A good reference is the risk assessment by Shipp et al. conducted for the Washington Department of Natural Resources. 2,4-D does not represent such hazards in its use as a rangeland herbicide.

OR-0238.

Comment No. 8: "The public perception of risk must be treated more seriously."

Response: In the second full paragraph on page 6 is reference to perception of risk, referring to an article by Paul Slovic, who is well known and respected for studies of the perception of risk. Slovic describes these phenomena, he does not assign values. The fact that risk is perceived to be high does not make risk greater than it is. Efforts by BLM to explain risks realistically are laudable. The agency has the obligation to explain risk on the basis of current knowledge, and should not assume that an activity has great risk because part of the society believes or states that it is so without evidence supporting the contention.

OR-0238.

Comment No. 9: "BLM must disclose the uncertainty and unknowns surrounding inert ingredients."

Response: The third full paragraph on page 7 is a general discussion of the failures of EPA in regulating inert ingredients, and speaks only peripherally to the questions pertinent to the draft EIS. Reference is made to an article in the Journal of Pesticide Reform by its editor, Mary O'Brien. Both the paragraph in question and the article make statements that are not consistent with the EPA Inerts Strategy as reported in a briefing to the Assistant Administrator for OPTS on February 6, 1990. Perhaps more pertinent are comments addressed to the question of inerts and contaminants in the Roundup formulation of glyphosate.

The implication in the comment and the article mentioned above is that the polyethoxylated amine is a highly toxic material, and that it finds a convenient hiding place as a list 3 inert. This surfactant is similar to those used in a wide variety of personal health and household cleaning products. Its toxicity is essentially the same as the surfactant in those products.

In attachment G and attachment H, another article by O'Brien, much is made of a letter to the editor of Lancet by Japanese physicians commenting on suicide attempts by Japanese, with Roundup. They comment that the severe gastrointestinal effects were caused by the surfactant, and discussed other symptoms. The responses of those patients are precisely what one would expect of ingestion of large amounts of surfactants, which are detergents. The same effect would have been accomplished with smaller quantities of dishwashing fluid. No chemical is free of toxicity, and suicide attempts have absolutely no bearing on the safety or lack thereof of herbicides. The observations do suggest, however, that it would be difficult to acquire a significant dose by accident.

As part of the argument in Attachment G, the statement is made that the surfactant is lethal to sockeye

fry at a concentration of 2.6 ppm, over a 96 hour exposure., and that it is 400 times more toxic that the Rodeo formulation, which has no surfactant. Reference is made to a paper by Servizi et al (Bull. Env. Cont. Tox 39:15, 1987) This paper reported studies of glyphosate alone, the surfactant alone and the Roundup formulation. The findings are not inconsistent with those of Folmar et al (Arch Envir. Cont. Tox. 8: 269, 1979) or by Mitchell et al (Bull. Envir. Contam. Tox. 39:1028).

It is in fact more toxic to fish than glyphosate, primarily because of the very limited toxicity of glyphosate. The intrinsic toxicity of the surfactants is a function of effects on gills and irritant responses that are analogous to those experienced when shampoo gets in the eyes. Surfactants are found in many formulations; Roundup is one of few in which the pesticide itself is less toxic than the surfactant.

If fish are to be the indicator, as presumably the most sensitive species, a finding of a 96 hour (four day) LC_{50} of 2.6 ppm indicates a rather low potential for effect. At 15% surfactant in the formulation, this suggests a formulation 96 hour LC_{50} of about 17 ppm. In fact the 96 hour LC_{50} for Roundup to fingerling and fry sockeye and rainbow trout fry was about 25 ppm. Coho were less sensitive. For perspective, a 2kg/hectare application of glyphosate, as Roundup, would carry with it 0.73 kg surfactant. It takes little arithmetic to show that if that application were laid directly on water 10 cm deep, the calculated concentration would be 0.073 ppm. To reach 25 ppm would require an application equivalent to 600-700 kg of glyphosate per hectare.

OR-0238.

Comment No. 10: "BLM must address the issue of 1,4-dioxane and POEA in glyphosate formulations."

Response: The concern expressed about the 1,4-dioxane contaminant of the surfactant is more appropriate. 1,4-dioxane is a condensation product of the ethylene oxide from which the long chain surfactant is synthesized.

The commenter has made an error at the top of page 8,in describing 350 ppm as 0.35% and relating this to other products containing 0.42 and 0.55% said to have prompted warnings to workers. 350 ppm is 0.035%

It is in fact carcinogenic when fed in the diet at daily doses over 1000 mg/kg, and produces kidney and liver lesions at doses in excess of 100 mg/kg/day. Inhalation studies produced no carcinogenic responses. It is genetically inactive; that is it does not have mutagenic activity. Its presence has been known in the formulation for about a decade by the manufacturer and EPA. It is also present in a very large number of personal health and cosmetic products containing this class of surfactant, and is an extensively used industrial solvent.

EPA in 1981 concluded that a 300 ppm contamination in the formulation was unlikely to result in adverse health effects. This conclusion is supported by risk estimations, consideration of the behavior of the material in the environment and very limited ability to penetrate the skin.

The present concentrations of 1,4-dioxane in Roundup are less than 30 ppm and do not represent a significant health risk.

OR-0238.

Comment No. 11: "Ammonium thiocyanate must be addressed in the EIS."

Response: See response to CO-0235, Comment No. 3.

OR-0238.

Comment No. 12: "BLM has not discussed problems with immune suppression as a potential toxic effect of using pesticides."

Response: As yet, a registration battery for immune effects of pesticides has not been established by regulatory agencies. It is generally agreed, however, that a lifetime exposure to a chemical, as in a carcinogenicity assay, without evidence of increased infectious disease is strong evidence that immune function has not been compromised. Absence of carcinogenicity adds to the strength of the evidence.

It is stated that the Region 6 EIS summary of 2,4-D effects "indicates that 2,4-D altered immune function, demonstrated effects on lymphocytes in utero and suppressed antibody production." The EIS has been misread and does not support the comment. Three papers are quoted in the EIS. Blakley and Schiefer (1986) conclude that the results suggest that 2,4-D esters are unlikely to have any major immunotoxicological significance. The suppressed antibody production mentioned was seen at a dose of 500 mg/kg (often a lethal dose), and were considered by the authors to be a secondary manifestation of clinical injury. In another paper (describing acute and subacute studies at "relatively high exposures") a similar conclusion was reached. (Blakley, 1986) In the teratological study (Blakley and Blakley, 1986) the EIS states that "no net suppressive effect was observed, and although subtle effects were noted in lymphocyte blastogenesis, the authors concluded that the 2,4-D ester was unlikely to be of any immunotoxicological significance."

OR-0238.

Comment No. 13: "BLM has not addressed the potential for 2,3,7,8-TCDD to be in 2,4-D."

Response: The referenced finding of TCDD in 2,4-D is the only known instance where such a finding has occurred, despite efforts by many investigators and EPA to find this contaminant. Inspection of the paper reveals that several compounds were analyzed, including pentachlorophenol and other materials expected to have high concentrations of TCDD and other chlorodioxins. The levels of TCDD in those materials was quite low, and that in 2,4-D was astonishingly high. This circumstance is not logical and highly suspicious, and indicates either external contamination from another source, or a sample made under very poor control of starting materials and reaction conditions. The 2,4-D used in this work was the only material for which a source was not identified. There has been an intensive effort by interested parties to find the source, and it now seems certain that the 2,4-D in question originated in eastern Europe.

This finding has no bearing on the purity of domestically produced 2,4-D.

UT-0239, Cheryl Grantham.

Comment No. 1: "The DEIS inadequately addresses the potential for groundwater contamination from the application of herbicides."

Response: We agree that the potential for ground water contamination from herbicides was not adequately addressed in the draft. We have incorporated several additions to the sections to address the ground water concerns.

UT-0239.

Comment No. 2: "The importance of the groundwater resource as a drinking water supply in these arid western states cannot be overemphasized... EPA has recently ranked the vulnerability of groundwater to contamination in each county in the U.S. ..."

Response: We agree. We have added additional emphasis to the use of ground water as a drinking water supply. See text for revised section. Also, see response to UT-0104.

UT-0239.

Comment No. 3: "According to EPA's current standard setting policy, these substances are not permitted to be present in public drinking water supplies at any detectable levels."

Response: We agree that there are many compounds for which drinking water standards are not developed. We do not believe that anything in the statement about drinking water standards implies that there are strict standards for all herbicides. Monitoring standards for many cases may be established by the state water quality regulator. Based on our standard operating procedures, any herbicides from our operations reaching the ground water in any level causing environmental or health effects would be unacceptable.

UT-0239.

Comment No. 4: "Several of the aquifers in the DEIS area are inherently susceptible to leaching and contamination...Consequently, both soil and aquifer characteristics common in this region make it impossible to dismiss the potential for contamination."

Response: We agree that the potential does exist in some areas. We did not intend to dismiss the potential. Rather, the impacts associated with a high potential area would have been mitigated through the application of standard procedures. We envision that the procedures would likely be adopted as Best Management Practices (BMPs) by the appropriate state agency. These procedures have been included under Mitigation.

UT-0239.

Comment No. 5: "Eight of the 19 herbicides proposed for use by BLM are ranked as having high leaching potential..."

Response: The DEIS listed very few data on the leaching potential of pesticides. Information has now been included where it is available.

The Surface Water Impacts and the Ground Water Impacts in the Chemical Methods of the Environmental Impacts Section have been rewritten to reflect the leachable pesticides identified in EPA (1987).

UT-0239.

Comment No. 6: "The DEIS does not attempt to quantify the increased sediment delivery to surface water that will be experienced due to reduction in vegetation...Many areas in the DEIS region have highly erodible, low organic-matter soils, considerable slope, and are subject to occasionally intense precipitation resulting in potentially severe soil erosion if vegetation is disturbed or eliminated."

Response: Quantification of project specific impacts is not within the scope of this document (see Tiering section). Both the Soils and Aquatic Resources section discuss the factors important in controlling erosion and subsequent sediment delivery. The possible impacts surrounding vegetation treatment are generally short term. In most cases it is expected that vegetation cover will increase in the long term, thus reducing erosion. The revegetation success coupled with the occurrence of extreme precipitation events will largely determine the fate of erosion. Many of the areas proposed for certain types of vegetation treatment will not meet the criteria described under Standard Operating Procedures (SOPs). We have expanded the SOP section to be more specific on the types of areas and conditions that will be avoided for soil disturbing/vegetation removal activities.

UT-0239.

Comment No. 7: "The most commonly used method of biological treatment is grazing by cattle, sheep, and goats. The effect of increased grazing on unstable soils, steep slopes, and in riparian areas is rarely negligible."

Response: Biological treatment using ungulates would be done in accordance with Standard Operating Procedures (SOPs). The following procedures were added to clarify where ungulates would not normally be used. Generally, biological methods using ungulates would avoid erosion hazard areas, areas of compactible soils, riparian areas susceptible to bank damage, and steep erodible slopes.

UT-0239.

Comment No. 8: "This increased sediment will undoubtedly have adverse impacts on fish and aquatic organisms. The extent of this impact is not addressed."

Response: See response to NM-0067.

UT-0239.

Comment No. 9: "In many areas the soil mantle is thin to nonexistent. The pH is typically high. This reduces the adsorption of ionizable herbicides such as 2,4-D, picloram and atrazine and increases the degradation time of others. Several of the aquifers in the DEIS area are inherently susceptible to leaching and contamination. The Columbia basalts are highly fractured and alluvial valley fill aquifers typically display considerable porosity. Consequently, both soil and aquifer characteristics common in this region make it impossible to dismiss the potential for contamination."

Response: A wide variety of soils and soil conditions exist in the EIS area. Soil parameters that affect the chemical persistence and degradation time along with many other factors will be considered during the site specific analysis of individual proposed vegetation treatments.

UT-0239.

Comment No. 10: "The DEIS does not attempt to quantify the increased sediment delivery to surface water that will be experienced due to reduction in vegetation. This increased sediment will undoubtedly have adverse impacts on fish and aquatic organisms. The extent of this impact is not addressed."

Response: The BLM recognizes the potential for increased sediment loads due to short term soil erosion caused by vegetation treatments. However, erosion potential, in terms of physical soil characteristics, slope, existing and potential ground cover, etc. will be evaluated on a project specific basis before any action takes place. Restrictions or mitigation of treatments to reduce the erosion potential may be applied on a site specific basis. As any other entity, the BLM must comply with individual state water quality standards.

UT-0239.

Comment No. 11: "The assumption of negligible impact from biological treatment methods needs to be reevaluated."

Response: When domestic animals are to be used as a biological treatment method they will be used specifically as a biological control agent and managed accordingly. In these situations animals are usually used to graze off the top portion of the plant to prevent flowering, then taken off or moved to a different area. In some situations it is necessary to return later in the growing season to remove the next flowering stage. When used in this manner impacts should be negligible.

Additional information has been provided in Chapter 1.

UT-0247, Christopher Biltoft.

Comment: "Selective tree removal should be used, if necessary, as an alternative to chaining."

Response: Even though "chaining" is a non-selective type treatment, it is one of the more inexpensive and efficient ways to accomplish the objectives of vegetation treatment in the pinyon/juniper type.

Selective tree removal is possible as a manual treatment method. However, it is labor intensive and could be implemented only on a small scale. As a result, it would not be practical to apply it to a project sufficient in scope to meet the objectives of (a) increased soil stability and (b) improved water quality. (See Chapter 3, Section 2.)

Also, in areas where artificial seeding is needed, chaining is an essential treatment for covering the seed with soil to enhance its germination. This would not be accomplished with a selective tree removal program.

UT-0252, Jane Lasson.

Comment No. 1: "The EIS... dismisses the value of ancient pinyon forests and bird, animal, and plant communities dependent upon them."

Response: See response to CO-0227, Comment No. 7.

UT-0252.

Comment No. 2: "The descriptions are simply too generalized thereby ignoring the extent to which, for instance, eradication of an ancient pinyon forest might have on potential uses of that area, or analyzing the impact of eradication a remnant stand of sagebrush on a remnant population of sage grouse."

Response: Part of the site-specific environmental analysis that will occur on the proposed projects, prior to their implementation, should include consideration of the significance of the vegetation communities as wildlife habitats. Statements on the consideration of old growth communities as important wildlife habitats have been added. Several statements have been added to the Final EIS, further emphasizing the significance of sagebrush habitat for sage grouse and the need for giving the interrelationship of these two species extra consideration (Chapters 1 and 3).

UT-0252.

Comment No. 3: "The plan states that most of the proposed treatments target upland sites, with the intent to improve or stabilize vegetation and watershed conditions.' Is the transformation of upland plant communities BLM's solution to the destruction of riparian areas from overgrazing?"

Response: Current BLM policy calls for a significant improvement in condition of riparian areas by 1997. Several of these vegetation treatments are planned to assist in the improvement of riparian areas through the improvement and stabilization of the adjacent upland vegetation communities. However, riparian areas cannot be permanently improved unless the watersheds feeding the riparian areas are also improving or in good condition. Riparian area management must be considered in a holistic view. Riparian areas and the adjacent uplands must be improved and managed together to achieve a lasting and significant watershed stabilization or improvement.

UT-0252.

Comment No. 4: "The program very clearly states that no additional employment would result from this plan (page 3-124)."

Response: The economic impact section states that "The increase in employment that would be required to implement Alternative 1 through 4 is not likely to be significant..." The text for alternative 5 is changed to indicate that new jobs would be created (Chapter 3).

UT-0252.

Comment No. 5: "The EIS states that recreation values on these unidentified, millions of acres constitute only 1% of the total value. Allocating only 1% to recreation is an arbitrary and capricious dedication of resources that I do not believe and support. This astounding figure represents a gross underestimation of the value these lands have to the public."

Response: The second paragraph on page 2-52 of the DEIS states, "Recreation management is intensively focused on 352 developed recreation areas, constituting approximately 5 percent of BLM-administered lands. Less than 1 percent of the total acreage considered in this EIS is recreation area." The one percent figure refers to acreage, not value, and relates **only** to intensively managed, developed recreation areas rather than all public lands. As the rest of the paragraph infers, **all** public lands, with few if any exceptions, are open to recreation. In the interest of clarification, this paragraph has been rewritten in the Final EIS.

UT-0252.

Comment No. 6: "BLM asserts that negative visual impacts would be short-term while long-term impacts would be beneficial. No justification or explanation is given."

Response: The eighth paragraph on page 3-59 of the Draft EIS stated in part, "Where areas are treated by methods that could significantly change visual contrast (quality), short-term adverse impacts of visual resources would occur. However, based on standard operating procedures and long range plans, the long-term impacts would be beneficial. The intensity of the impact would depend on the treatment method and the area where it was implemented." Explanations are given in succeeding paragraphs which discuss both short and long-term impacts and benefits of each vegetation treatment method.

UT-0252.

Comment No. 7: "It oversimplifies and dismisses a very real potential for widespread groundwater contamination from spraying herbicides." The letter also includes several comments on monitoring.

Response: See responses to UT-0239, and UT-0104.

UT-0252.

Comment No. 8: "The lack of a benefit analysis is a violation of the Council on Environmental Quality's national Environmental Policy Act (NEPA) regulations 40 CFR 1502.23."

Response: CEQ does not require a cost-benefit analysis. If one is done then it must be incorporated by reference or appended to the statement.

UT-0252.

Comment No. 9: "NEPA's cost-benefit analysis section states "an environmental impact statement should at least indicate those considerations (merits and drawbacks of various alternatives) including factors not related to environmental quality, which are likely to be relevant and important to the decision" (40 CFR 1502.23). While the BLM has identified primary beneficiaries of the proposed treatment, quantification of these benefits, which we view as entirely relevant to the decision, are ignored."

Response: CEQ does not require benefits to be quantified. Section 1502.23 states "For purposes of complying with the Act, the weighing of the merits and drawbacks of the various alternatives need not be displayed in a monetary cost-benefit analysis and should not be when there are important qualitative considerations."

UT-0253, Christine Osborne.

Comment No. 1: "The methods of vegetative treatment proposed can be destructive to both target and non-target species. Disruption of native plant ecosystems, displacement of wildlife, and chemical toxicity to plants, animals, and water sources need to be examined in detail before plans of such a large extent can be recommended."

Response: See response to NM-0073 Comment No. 2.

UT-0253.

Comment No. 2: "The annual acreage proposed for treatment appears as a set of arbitrary numbers based only loosely on current resource management plans."

Response: Acreages will be determined as specific on-the-ground site plans are developed and specific environmental analyses are completed. The BLM will not exceed the acres projected in Tables 1-2 through 1-6 on an average annual basis over the life of the EIS. Acreage figures shown are representative of decisions made in existing land-use plans.

Available funds, availability of seed, and available manpower all influence how much actual land treatment will be completed in any given year.

The rate of spread of noxious weeds is very difficult to predict. As new biological control agents become available, some of the chemical control proposed may be reduced. Climate cycles also influence the rate of spread of noxious weeds.

UT-0253.

Comment No. 3: "In a 1975 symposium at USU, range scientists concluded that most chainings failed to deliver on their promises, with the majority of chained areas eventually reverting back to woodland. This is confirmed by the large number of second treatments applied to previously chained areas."

Response: A great deal has been learned about site selection and project design and there are many areas with demonstrated non-livestock benefits from type conversion of woodlands. Type conversions provide an opportunity to establish palatable shrub ecotypes (such as sagebrush, rabbitbrush, and bitterbrush) and forbs that provide much

needed protein and early spring forage for wildlife otherwise not available in sufficient abundance in some woodland areas. With design features to provide sufficient hiding cover to allow wildlife to use available forage, conversions can be of real benefit in areas where low seasonal forage quality and quantity are limitations to some wildlife species.

Failure of the technique is not, however, demonstrated by second treatments applied. Vegetation is dynamic and communities change over time. This is a fundamental aspect of plant ecology and successional theory. A follow-up treatment, such as prescribed fire, applied within a year or two after initial treatment, is just the second step of a two-step treatment prescription. Much of both the upper and lower boundaries of the pinyon-juniper type can be viewed as a woodland/shrubland/grassland interface or tension zone, which can be dominated by one lifeform or another depending on disturbance regimes such as fire, herbivory, and drought in combination with other climatic factors and soil characteristics, and where natural fluctuations between dominate types are common. Most converted woodlands would not be expected to remain dominated by herbaceous vegetation even in the total absence of herbivory (livestock, wild ungulates, rodents) without some sort of periodic disturbance that gave a competitive edge to the herbaceous components, barring a significant climatic change. Prior to European settlement, disturbance regimes maintained some sites in herbaceous cover that may have been woodland in the absence of such disturbance. Type conversion simply applies this principal to selected sites where it is determined that such treatment is the best way to meet various land use objectives.

UT-0253.

Comment No. 4: "It would seem mandatory that these questions are clarified or the entire proposal is simply an administrative exercise in justifying the existence of these range improvement projects."

Response: This EIS not only addresses vegetation treatment for rangeland, but also addresses public domain forests, oil and gas sites and facilities, rights-of-ways, and recreation sites in addition to noxious weed control in the states of Nevada, Utah, Colorado, North Dakota, South Dakota, Arizona, New Mexico and Oklahoma. The proposed annual acreage is an average dependent upon budgetary constraints.

UT-0253.

Comment No. 5: "The comment letter, in several places, raises concern about ground water."

Response: See responses to UT-0239, and UT-0104.

UT-0254, Dee Hansen.

Comment: "Research has also demonstrated that vegetation manipulation is important to maintain good watershed condition."

Response: See responses to AZ-0088, and UT-0239.

UT-0255, James E. Bowns.

Comment: "Many stands of sagebrush are similar to the Pinyon-Juniper stands because they also lack understory or associated species. Improved management systems or complete elimination of livestock will not change this situation. The only way to increase the production of desired plants is to reduce the amount of sagebrush and seed the area to desired species. Sagebrush can be reduced by treatment. Seeding with desirable grasses, forbs and shrubs is necessary where native understory is lacking."

Response: Refer to revised text in Chapter 1, Weed Management Treatments and Design Features, Chapter 2, and common issue Noxious Weed Management in Chapter 4.

UT-0256, Michael Heyrend.

Comment No. 1: "Concentration of these chemicals in the air and water can result in contamination of these resources." (Followed by discussions of amitrole, atrazine, picloram, triclopyr, and 2,4-D).

Response: To recognize the potential for impacts to wildlife the following statement has been added to the Mitigation section (Chapter 1) and into the impacts evaluation sections (Chapter 3). "To minimize impacts to fish and other aquatic wildlife, amitrole and dalapon are no longer proposed for use, and the use of atrazine, clopyralid, dalapon, diuron, simazine, triclopyr (butoxyethyl ester only), 2,4-D, or diesel oil carriers will be very carefully regulated and applied when the treatment area is adjacent to aquatic habitats."

UT-0256.

Comment No. 2: "Herbicides adversely impact fish reproduction and growth, and indigenous wildlife populations The bioaccumulation of toxins in fish and game species poses a significant threat to the health and welfare of these populations."

Response: See responses to NM-0073, Comment No. 2, and UT-0114, Comment No. 3.

UT-0256.

Comment No. 3: "... soil disturbance due to mechanical clearing will increase sediment levels in streams. Sediment effectively destroys areas important for fish spawning."

Response: Please refer to UT-0239, comments number 8 and 9..

UT-0256.

Comment No. 4: "Amitrole, for instance has been designated by the EPA as probable human carcinogen and can persist in plants, animals and water."

Response: See response to CO-0235, Comment No. 3.

UT-0256.

Comment No. 5: "Atrazine is probably the most common pesticide contaminant of groundwater and is acutely toxic to aquatic invertebrates and amphibians."

Response: See response to OR-0238, Comment No. 2 which deals with groundwater concerns.

UT-0256.

Comment No. 6: "...a new National Cancer Center Institute study of lymphoma contraction in Kansas farmers found significant links with atrazine."

Response: The study by Hoar, et al., based its triazine conclusions on only 3 cases of NHL. This study has been reviewed extensively and shows an equivocal link between herbicides and cancer, not conclusive proof.

UT-0256.

Comment No. 7: "2,4-D increases risk of contracting lymphoma and peripheral neuropathy in humans."

Response: See responses to OR-0238, Comments No. 6 and No. 7.

UT-0256.

Comment No. 8: "...the indirect impacts of bioaccumulation...woefully neglected."

Response: See Appendix E8-1 for a discussion of expected bioaccumulation at the top of column 2.

UT-0256.

Comment No. 9: "The lack of a benefit analysis is a violation of the Council on Environmental Quality's national Environmental Policy Act (NEPA) regulations 40 CFR 1502.23."

Response: See response to UT-0252.

UT-0256.

Comment No. 10: "NEPA's cost-benefit analysis section states "an environmental impact statement should at least indicate those considerations (merits and drawbacks of various alternatives) including factors not related to environmental quality, which are likely to be relevant and important to the decision" (40 CFR 1502.23). While the BLM has identified primary beneficiaries of the proposed treatment, quantification of these benefits, which we view as entirely relevant to the decision, are ignored."

Response: See response to UT-0252.

UT-0256.

Comment No. 11: "In addition, the DEIS ignores the substantial indirect costs of the proposed activities."

Response: See p. 3-126 in the draft EIS for a discussion of indirect economic impacts and FEIS, Chapter 3.

UT-0256.

Comment No. 12: "The BLM fails to recognize in the DEIS that many areas currently under multiple use are under consideration for wilderness through bills presently before Congress (e.g. HR 1500). No special management of these areas is proposed by the agency even though Congressional support for this legislation is manifest through increasing numbers of co-sponsors. The DEIS should view these areas as "Areas of Special Consideration (ASC)" for their

qualities that distinguish them as potential wilderness areas. In these ASCs, vegetation treatment activities should be banned so that these areas can maintain the values which the public, as represented by Congress, aims to preserve."

Response: The fact that many BLM areas currently under multiple use management are under consideration for designation as wilderness through bills presently before Congress does not change existing BLM management policy, practice, or procedure. Areas currently under multiple use management will continue to be managed under the principles of multiple use, regardless of whether they are being considered in specialized legislation for designation as wilderness. Areas that have been declared Wilderness Study Areas (WSAs) will continue to be managed in accordance with the Bureau's Interim Management Policy and Guidelines For Lands Under Wilderness Review (Update Document H-8550-1 dated 11/10/87), which assures wilderness character will not be irreparably damaged. BLM policy and management practice with regard to vegetation treatment in designated wilderness areas and WSAs is briefly described on pages 1-24 and 1-25 of the Draft EIS and in more detail on pages 3-62 and 3-63.

UT-0256.

Comment No. 13: "Native American religious and cultural concerns are not being addressed in the EIS."

Response: See response to MT-0112, Comment No. 1.

UT-0258, Chris Call.

Comment No. 2: "The first sentence on the second column, page Exec-4 summary is not correct. It states that seedbanks reduce the susceptibility of plants to herbicides."

Response: The text has been revised.

UT-0258.

Comment No. 3: "The sentence, 'Nontarget plant species should reestablish after treatment,' in the vegetation section under the Environmental Consequences heading (p. Exec-3) is broad-sweeping, and has little support. Delete the sentence or support it by describing the types of nontarget species responses or the time frame for reestablishment."

Response: The sentence was deleted from the Executive Summary in the Final EIS, as it is not practical to detail supporting material in this section. Principles governing nontarget species response and reestablishment were discussed for each treatment method in DEIS Chapter 3, Section 1, pages 3-5 through 3-29.

UT-0258.

Comment No. 4: "The first sentence of the 2nd paragraph on p. Exec-4 is not totally correct. Under certain environmental conditions, e.g. drought, resprouting woody species such as rabbitbrushes, mesquite, and acacias can replace above-ground structures more rapidly than herbaceous species because they may have more extensive root systems to tap deep soil moisture."

Response: Paragraph has been revised.

UT-0258.

Comment No. 5: "The sentence at the top of the 2nd column on page Exec-4 states that seedbanks reduce the susceptibility of plants to herbicides. That is not the case; seedbanks increase the regenerative capacity of species after treatment, but they have no bearing on susceptibility of the plant to herbicides."

Response: The statement "seedbanks reduce the susceptibility of plants to herbicides" is incorrect. However the regeneration capacity of species from seedbanks after treatment is dependent upon the residual affect from the herbicide upon the new seedlings. Therefore one must consider which herbicides should or should not be used to cause the least or no effects on the seedbank of the nontarget or desired plant species.

UT-0258.

Comment No. 6: "You may want to check with the manufacturer about the future use of atrazine on rangelands. I have heard that it will not be re-registered for use on rangelands."

Response: The determination has not been made at the present time whether or not atrazine will be re-registered for use on rangelands. If atrazine is not

re-registered the use will be cancelled as appropriate.

UT-0258.

Comment No. 7: "The sentence 'Nontarget plant species should reestablish after treatment,' on page Exec-3 is broad sweeping, and has little support. Delete the sentence or support it by describing the types of nontarget species responses or the time frame for reestablishment."

Response: The sentence "Nontarget plant species should reestablish after treatment" has been deleted from the text. There are many variables that must be considered when considering any treatment method. When considering any treatment method one has to consider the growth characteristics, sensitivity to the treatment method, life span etc. of both the target and nontarget plant species present at the time of treatment.

UT-0258.

Comment No. 8: "On page 1-11 and on page C-3 in the Appendix, you distinguish between microbial and viral agents and plant pathogens as different biological treatments. Plant pathogens, e.g. fungi, bacteria, and viruses, are considered microbes. Also on page C-3, you distinguish between genetic improvements of plant adaptability and reproduction and interspecific plant competition as different biological control treatments. They are similar."

Response: See revised text on biological treatments in Chapter 1, and biological methods in Appendix C.

UT-0258.

Comment No. 9: "Revegetation is a vegetation manipulation treatment, and it should be discussed in adequate detail so the reader can understand the associated impacts."

Response: Not all treatments proposed will require revegetation. The need for revegetation will be determined as site-specific treatments are proposed in local activity plans for watershed, wildlife, livestock grazing, or fire management. Section 1 of Chapter 3 discusses circumstances when revegetation is recommended in conjuction with various treatment methods in all analysis regions. Site-specific impacts of revegetation will be addressed in site-specific analyses conducted prior to treatment. Analysis region-level impacts are discussed in Section 2, Chapter 3.

UT-0262, Chuck Woolstein.

Comment No. 1: ". . . recommend that the BLM and others involved in chaining establish an external advisory board of professional scientists. . . to review each proposed site for chaining with regard to research questions of biology, archeology, anthropology, paleontology, soil science hydrology, etc."

Response: Establishment of an independent advisory board would not be practical due to the size and geographical scope of chaining projects. Each District has a charter Multiple Use Advisory Board along with a District Grazing Advisory Board. Notification of these meetings and items to be discussed are published in the Federal Register. Interested individuals are welcome to attend these meetings and provide comments on proposed projects.

UT-0262.

Comment No. 2: "Cultural resources need to be addressed in project specific environmental analyses."

Response: See response to WY-0085.

UT-0264, Gary McFarlane.

Comment No. 1: "The EIS, particularly in the summary, overstates the benefits of maximizing vegetation treatment. For example, alternative 1 would not necessarily have the most beneficial impact on wildlife, (Exec-5). Vegetation treatment may help mule deer in specific areas but, as the EIS later notes, Any change in community vegetation structure or composition is likely to be favorable to certain animal species and unfavorable to others.' (page 3-46). Most of the species aided by vegetation treatments are not in danger whereas many species dependent on specific habitats are less stable and they are the ones most likely to be harmed from vegetation treatments."

Response: The Executive Summary (Exec-5) has been rewritten in the Final EIS to better reflect the potential impacts to fish and wildlife as well as the expected impacts. The impact analysis portions have been revised with this same type of structure to give a better understanding and support for why the statements of impacts were made, and to support the addition of more detailed mitigation.

Habitat treatments should not jeopardize a special status species for the benefit of a common species, even if the common species is of significant economic importance. It is suitable, however, to improve habitat for a common species when there

are no significant adverse impacts to special status species and the common species will receive a significant habitat benefit with a carry-over benefit to hunters or other wildlife recreation users.

UT-0264.

Comment No. 2. "The EIS is unclear as to whether vegetation manipulation would be allowed in WSAs and wilderness areas. It is clear the IMP and Wilderness Act prohibit any chemical or mechanical treatments."

Response: The EIS is quite clear as to whether vegetation manipulation would be allowed in WSAs and wilderness areas. See pages 1-24, 1-25, 3-62, and 3-63 of the Draft EIS for descriptions of BLM policy and management practice, and those same sections are present in the Final EIS.

UT-0265, Genevieve Attwood.

Comment: "How does chaining foster natural biological diversity and ecological stability within the Colorado Plateau? What is the ecological impact of chaining a pinyon-juniper woodland during a drought cycle?"

Response: Disturbing a vegetation type that has a demonstrated history of disturbance (refer to Pinyon-Juniper analysis region description in Chapter 2), portions of which contained a productive and sometimes dominant herbaceous element as a result of this disturbance, and which has been documented to have expanded both its density and range in some areas can be viewed as an attempt to mimic these past disturbance regimes. Present woodland conditions which are a result of historic overgrazing and fire exclusion should not be viewed as representing any sort of benchmark for natural biological diversity or ecological stability on the Colorado Plateau. The small amount of chaining acreage proposed is not anticipated to have significant effects on either natural biological diversity or ecological stability within the Colorado Plateau. We would expect ecological impact of chaining a woodland during a drought cycle to be slower recovery and establishment of vegetation in general.

Results following chaining and seeding usually show a greater variety of plant species being produced which fosters an increase in bio-diversity and a greater production of forage for grazing animals. Pinyon-juniper (P-J) chainings and seedings during a drought are more risky than during a wet cycle. However, most of the various seeds remain viable for an extended period and will continue to germinate for up to several years.

Also, revegetated areas produce early spring plant growth which supplies forage to lactating animals - both livestock and wildlife.

UT-0269, Roger Banner.

Comment: "Also, a general assessment of impacts that might be expected from changing the vegetation from one cover type to another on carbon fixation, retention and release may strengthen the final EIS by assessing expected impacts of managing or not managing the vegetation. Ultimately, comparisons of the various vegetation types in terms of estimated net carbon fixed, held and released into the atmosphere would need to be made. This information would need to be placed in perspective relative to the significance of the effect and current scientific information."

Response: See response to UT-0130.

UT-0271, Allen Rasmussen.

Comment: "The revegetation process following many of the techniques are critical in the success or failure of the project. While it was noted that if revegetation is successful many negative impacts are minimized, revegetation failures resulted in degradation primarily of soil loss or an undesired plant composition. The techniques which are going to be used should be considered."

Response: This concern has been incorporated into the discussion of Standard Operating Procedures in Chapter 1.

UT-0274, James Catlin.

Comment No. 1: "Monitoring of wildlife by BLM is extremely rare. The state does monitor game species. Without this base of information, it is impossible to assess the impacts of these range projects or changes in domestic livestock use."

Response: The Fish and Wildlife program in the BLM is evolving from a support program for commodity uses into a full resource management program. Fish and Wildlife 2000 and the supporting subdivided "strategies," have demonstrated the extent of the resource to be managed by the BLM and the need for better management.

UT-0274.

Comment No. 2: "...the most preferred and easily damaged plants in riparian areas should be monitored."

Response: Recent emphasis on the management of riparian areas on the public lands has demonstrated the need to more actively manage the riparian resource and to monitor the effects of land uses on that resource. As management plans and activity plans, such as allotment management plans and habitat management plans, are revised and developed there will added emphasis on monitoring and improved management of riparian areas on public lands.

UT-0274.

Comment No. 3: "The DEIS needs to identify relic plant communities and prohibit any vegetation alteration projects, including use by domestic livestock. Access by vehicles and domestic livestock needs to be restricted or eliminated."

Response: BLM recognizes the scientific and natural value of relic plant communities and tries to identify and protect them wherever they can be found. These areas are often designated as Areas of Critical Environmental Concern or Research Natural Areas. The ecological role and frequency of disturbance in maintaining that community must be determined and understood. Prescribed fire might be recommended in some of these areas, but other vegetation alteration, including grazing by domestic livestock, normally would not be proposed. If certain known relict areas have been proposed for prescribed burning as part of the proposed action or one of the other alternatives, impact analysis and fire effects do not have to be addressed separately for these areas. Their identification, protection, and details of their management however, are beyond the scope and purpose of the EIS.

UT-0274.

Comment No. 4: "The DEIS needs to address the issue of what plants and animals are considered pests."

Response: Refer to Appendix I for the list of plants that will be considered for treatment.

UT-0274.

Comment No. 5: "Biological management alternatives have the greater potential for improving the public range lands."

Response: Biological pest management is only one portion of an overall pest management program. See revised text in Chapter 1 under Biological treatments and Project design features sections.

UT-0274.

Comment No. 6: "Many BLM lands are now under wilderness study. The DEIS fails to describe which treatment projects affect specific areas. This needs to be done in the EIS."

Response: See UT-0256, Comment No. 8.

UT-0274.

Comment No. 7: The comment letter raises concern about the need for water quality monitoring.

Response: See responses to UT-0104, and UT-0239.

UT-0274.

Comment No. 8: "For each of the chemicals listed in the DEIS we request references of studies supported by the EPA on cancer studies, birth defect studies, and mutation studies."

Response: In the Appendix, page E3-1, there is a section on Sources of Toxicity Information. The final sentences read, "Whenever possible, studies that EPA reviewed and validated were used to set toxicity reference levels. No EPA-invalidated studies were used."

UT-0285, Nicholas Gardiner.

Comment No. 1: "The document does not address the ecological structure and conditions of microclimates and ecotones within the very broad vegetative categories of the DEIS."

Response: See response to CO-0115, and Common Issues earlier in this chapter.

UT-0285.

Comment No. 2: "Cultural resources need to be addressed in project specific environmental analyses."

Response: See response to WY-0085.

UT-0292, Susan Way.

Comment No. 1: "The oxygen given off by the pinyon pine and juniper is essential to life - this is our rainforest - the loss of water produced by our desert forests will cause an increased drought to our already existing drought."

Response: See response to UT-0130.

UT-0292.

Comment No. 2: "Chaining pinyon-juniper will lead to erosion and loss of habitat and food - upsetting the ecological balance - causing the loss of native wildlife."

Response: The existing ecological balance will be upset some for birds and other small animals. However, by adherence to the mitigation and project design features sections, i.e., by leaving islands of trees and irregular boundaries for edge effect, this will be minimized and the net effect will be an enhancement of habitat through a bio-diverse vegetative structure and greater forage value for grazing animals, as well as an improved watershed condition.

CO-2525, Scott Felker.

Comment: "1. The DEIS does not address the structure of ecotones and microclimates within the various vegetation types in the west. BLM is making far too many generalizations regarding this."

Response: See response to CO-0115.

WY-2533, David Neary.

Comment No. 1: "There are several problems with the list of target plant species contained in Appendix I. It is incomplete (e.g. Canada thistle is not listed for Wyoming), confusing (no explanation is given as to purpose of the list) and inaccurate (e.g. several species listed for Wyoming do not occur here)."

Response: Appendix I has been revised.

WY-2533.

Comment No. 2: "Herbicides are not target-specific, and numerous non-target species would suffer from indiscriminate applications such as those proposed in the EIS."

Response: The use of herbicides could result in a decrease of species richness. However, during site specific analysis and preliminary planning, some of the considerations taken will be: growth characteristics, sensitivity to treatment method, stage of growth, life span etc. of both the target and non-target plant species at the time of treatment. In many circumstances the time of treatment, rate of application of the herbicide, or both, is different than the most ideal time or rate to control the target plant species in order to minimize damage to the nontarget plant species. During the site specific analysis the toxicity, exposure and risk of herbicide use in relation to native plant species will be considered in determining treatment method and time of treatment.

WY-2533.

Comment No. 3: "Several of the programs described in the EIS, such as oil/gas site maintenance and range "improvement," would actually increase the risk of noxious weed invasion—by eliminating native vegetation and opening habitat for unwanted invaders."

Response: The use of herbicides for oil/gas site maintenance, rights-of-way maintenance, and recreation site maintenance in many situations is for safety factors whereby the removal of **all** vegetation is required. Range improvement programs are selected for release of selected native species by competition reduction. In certain situations the treatment site will be reseeded with desired native plant species.

WY-2533.

Comment No. 4: "Prescribed burning is considered with herbicide use. Vegetation management through burning should be considered separately as objectives, results and philosophy are very different from the herbicide use."

Response: Both prescribed burning and herbicide use are considered vegetation treatments. Therefore, it is proper to cover both of them in this document.

WY-2533.

Comment No. 5: "Is BLM aware of possibly destroying non-target native plants?"

Response: Page E2-2 of the draft EIS Application Methods and Herbicide Use states, "...applications are scheduled and designed so that there will be minimal potential impacts on nontarget plants and animals..."

OR-2539, Nick Facaros.

Comment No. 1: "The proposed use of diuron is unjustifiable because data on the herbicide are inadequate to assess risk, as the BLM concluded in the draft proposed record of decision for managing competing vegetation in Western Oregon."

Response: Table E3-7, page E3-33 of the DEIS lists the data gaps for diuron. Pages E3-51 and 52 summarize the known diuron data. EPA has established a reference dose of 0.002 mg/kg/day.

OR-2539.

Comment No. 2: "What makes the assumption 'conservative' and 'likely to exaggerate risks,' when BLM uses them to describe carcinogenicity?"

Response: See page E3-11 in the DEIS for an explanation of carcinogenicity tests and how they are used to derive cancer potency values. The second paragraph of the second column gives the assumptions that are made and explains why they are conservative.

CO-2543, Jeff McWhirter.

Comment: "Many things such as water contamination, ...are not adequately covered in this document."

Response: See responses to UT-0239, and UT-0104.

UT-2569, Stephen Trimble.

Comment: "Chainings fail to deliver on their promises and are an archaic, unproductive and destructive act."

Response: The encroachment of pinyon-juniper trees into areas where they did not previously exist is a fairly major problem which has increased since fire suppression, and development of much of the west. The expansion has been primarily into the sagebrush grass community on the lower edges of the original pinyon-juniper. If unchecked, trees become dominant and eventually crowd out most herbaceous and shrub species that provide forage for livestock and big game (Barney & Frischknecht 1974). This expansion continues even if areas are protected from grazing. Trees maintain increased growth for two or three times as long as any understory cover, resulting in a steady reduction of understory cover and production (Tausch and Tueller 1977).

A majority of the fall, winter, and spring big game and livestock ranges in the Great Basin are located in the pinyon-juniper type. Modern methods and materials when applied can result in improved wildlife value compared to values that have been derived from older pinyon-juniper projects. The goal of most pinyon-juniper range improvement projects has been to eliminate competitive trees and to seed or otherwise establish more desirable species (Stevens 1986).

Sedwick and Ryder (1987) found many bird species respond negatively to chaining. However small mammal species richness was greater on the chained plot than on the unchained control plot. Chained areas are more valuable for certain raptors as well as mammalian carnivores.

NM-2572, James Jones.

Comment No. 1: "...meets the objective of improving the rangelands...by not allowing treatment that adversely affects riparian areas - both the larger drainages and the smaller tributaries."

Response: The rationale and mitigation for avoiding adverse impacts to riparian areas (page 1-23 in the DEIS) has been expanded in the Final EIS. The intent of this document is that vegetation treatments will not have adverse impacts on riparian areas and aquatic habitats. Also, it is believed that improvements can be made in the condition of riparian areas through improved management of livestock, better engineering of roads and other impacting activities, and better overall management of all activities in riparian areas. Our successes in Montana, Oregon, Arizona, and many other places have demonstrated that this is possible. In situations that are severely degraded, a temporary removal of livestock may be warranted, but with improved condition and management, permanent removal should not be necessary.

NM-2572.

Comment No. 2: "Killing woody plants will increase soil erosion, a problem of considerable concern since soil erosion is already a serious problem in this area, and all over New Mexico."

Response: Please refer to UT-0239.

NM-2572.

Comment No. 3: "Another large concern is the contamination of surface and ground water by pesticides used to kill plants. Private wells are common in this area and could easily be contaminated as they are typically not very deep."

Response: See responses to UT-0239, and UT-0104.

AZ-2574, Linda Wells.

Comment No. 1: "The only wildlife that seem to benefit from your plan are a few species that incidentally improve with livestock grazing. Wildlife improvement is certainly the exception and not the rule when an area is grazed by livestock. There is only so much forage and no matter what management technique is used cattle displace wildlife."

Response: There are also many instances where wildlife have received significant benefits from vegetation treatments, and some of these have been fully funded by the range management program. It is not easy to make clear statements as to the actual impacts of treatments to wildlife or of the impacts to wildlife of livestock grazing. In some situations grazing by livestock has been proven to be beneficial to wintering wildlife, and the lack of grazing has been demonstrated to be adverse to wildlife (Frisina and Morin 1989). Heavy livestock grazing has often been beneficial to mule deer habitat, while moderate grazing may be detrimental to mule deer and beneficial to elk. These wildlife and livestock relationships are very complex and of course vary from species to species. Current regulations allow livestock grazing on public lands and the most beneficial course of action is to manage for the best wildlife populations possible in conjunction with this grazing use. The impacts to wildlife sections have been amended to include discussions of more of the potential adverse impacts of improperly applied vegetation treatments to wildlife. Also, mitigation has been added to reinforce the protection of crucial wildlife values.

AZ-2574.

Comment No. 2: "In the draft there are 33 pages analyzing the impact of chemical methods on humans and less than a page on the effects on wildlife. The main consideration for the timing of aerial applications of herbicides is the potential risk to humans consuming wildlife that have eaten herbicide contaminated forage."

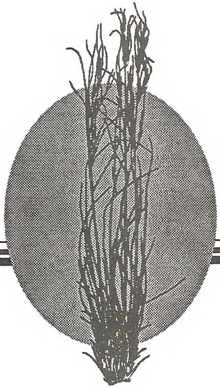
Response: Appendix E, sections 6, 7, and 8 summarize impacts of herbicides on wildlife. Additional discussion of impacts of herbicides to wildlife and mitigation has been included in the Final EIS.

AZ-2574.

Comment No. 3: "BLM lands contain 45 of the federally listed threatened and endangered species and many others that are being considered for listing The number of species that are listed and the methods of vegetation management that you propose would simply add to already stressed ecosystems."

Response: Various laws and regulations allow for management of livestock to mitigate or eliminate adverse impacts of grazing on T. and E., or special status species. In order for this to take place, the direct impact must be demonstrated and the livestock managed or numbers reduced to the level where no significant adverse impacts are further occurring to the wildlife species.

Chapter 5
List of Preparers



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REFERENCES

Agnello, A. M., J. R. Bradley, Jr., J. W. Van Duyn. 1986a. Plant-mediated effects of postemergence herbicides on Epilachna varivestis (*Coleoptera: Coccinellidae*). *Environmental Entomology*. 15:216-220.

Agnello, A. M., J. R. Bradley, Jr., J. W. Van Duyn. 1986b. Influence of postemergence herbicides on populations of bean leaf beetle, *Cerotoma trifurcata* (*Coleoptera: Chrysomelidae*) and corn earworm, *Heliothis zea* (*Lepidoptera: Noctuidae*), in soybeans. *Journal of Economic Entomology 81* (1):290-292.

Agrochemicals Handbook. 1988. Clopyralid File. Palo Alto, CA: Dialog Information Services, Inc.

Agrochemicals Handbook. 1989. Clopyralid File. Dialog Information Services, Inc. Palo Alto, CA.

Agrochemicals Handbook 1989. Mefluidide File. Palo Alto, CA: Dialog Information Services, Inc.

Ahlenslager, K. 1986a. Pascopyrum smithii. In Fire effects information system (data base), comp. William C. Fischer. Missoula, MT: United States Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory.

Ahlenslager, K. 1986b. *Tetradymia canescens.*

Ahlenslager, K. 1986c. *Tetradymia glabrata.*

Ahlenslager, K. 1987a. *Elymus elymoides.*

Ahlenslager, K. 1987b. *Taeniatherum caput-medusae.*

Ahlenslager, K. 1988. *Sporobolus cryptandrus.*

Ahlgren, I. F., and C. E. Ahlgren. 1960. Ecological effects of forest fires. *Botanical Review* 26:483-535.

Ahlgren, I. F., and C. E. Ahlgren. 1965. Effects of prescribed burning on soil microorganisms in a Minnesota jack pine forest. *Ecology* 46:304-310.

Albini, F. A. 1976. Estimating wildfire behavior and effects. General Technical Report INT-30. Ogden, UT: United States Department of Agriculture, Forest Service, Intermountain Research Station.

Aller, L., T. Bennett, J. H. Lehr, and R. J. Petty, 1985. DRASTIC: A standardized system for evaluating ground water pollution potential using hydrogeologic settings. EPA/600/2-85/018. Ada, Okla., 130 pp.

Ali, S. 1984. Knapweed eradication program in Alberta. In Proceedings of the Knapweed Symposium. Bulletin 1315. Bozeman: Montana State University, Plant and Soil Science Department and Cooperative Extension Service.Alley, H. P. 1956. Chemical control of big sagebrush and its effect upon production and utilization of native grass species. *Weeds* 4:164-173.

Altman, P. L., and D. S. Dittmer, eds. 1962. Growth: Including reproduction and morphological development. Washington, DC: Federation of American Society of Experimental Biology.

American Cyanamid Company. 1985. Arsenal herbicide for brush control and forest management. Princeton, NJ: Agricultural Research Division.

American Cyanamid Company. 1986. Summary of toxicology data on imazapyr and Arsenal. Princeton, NJ: Agricultural Research Division.

American Fisheries Society, Western Division. 1980. Position Paper on management and protection of western riparian stream ecosystems.

American Petroleum Institute. 1982. Index and abstracts for reports and other publications. Project no. 1597. Medicine and Biological Science Department. Washington, DC: American Petroleum Institute.

American Petroleum Institute. 1983. 28-day dermal toxicity study in the rabbit, hydrodesulfurized kerosene sample 81-07. American Petroleum Institute medical research publication no. 30-32297.

American Petroleum Institute. 1983b. Carcinogenic potential of key petroleum products. *American Petroleum Institute Medical Research Publication no. 30-31646.*

Andersen, J. W. 1975. Laboratory studies on the effects of oil on marine organisms: An overview. American Petroleum Institute Publication no. 4249.

Andersen, K. J., E. G. Leighty, and M. T. Takahashi. 1972. Evaluation of herbicides for possible mutagenic properties. *Journal of Agriculture and Food Chemistry* 20:649-656.

Anderson, H. A. 1982. Aids to determining fuel models for estimating fire behavior. General Technical Report INT-122. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station.

Anderson, K. L., E. F. Smith, and C. E. Owensby. 1970. Burning bluestem range. *Journal of Range Management* 23:81-92.

Arnett, R. H., Jr., and R. L. Jacques, Jr. 1981. *Guide to insects.* New York: Simon and Schuster Inc.

Arnold, W. R., and P. W. Santelmann. 1966. The response of native grasses and forbs to picloram. *Weeds* 14:74-76.

Aro, R. S. 1971. Evaluation of pinyon-juniper conversion to grassland. *Journal of Range Management* 24:188-197.

Aro, R. S. 1975. Pinyon-juniper woodland manipulation with mechanical methods. In *The pinyon-juniper ecosystem: A symposium*, eds. G. F. Figgor and F. E. Busby. Logan, UT: Utah State University.

Austin, D. D., and P. J. Urness. 1983. Overwinter forage selection by mule deer on seeded big sagebrush-grass range. *Journal of Wildlife Management* 47:1203-1207.

Bahler, C. C., K. P. Vogel, and L. E. Moser. 1984. Atrazine tolerance in warm-season grass seedlings. *Agronomy Journal* 76:891-895.

Baker, J. N. 1958. Effect of gibberellic acid, 2,4-D, and indoleacetic acid on seed germination and epicotyl and radiele growth of intermediate and pubescent wheatgrass. *Journal of Range Management* 11:227-230.

Baker, L. 1983. A priority listing and brief economic analysis of weed species for potential biological control in Montana. Unpublished report. Bozeman: Montana State University, Department of Plant and Soil Sciences.

Baker, M. F., and N. C. Frischknecht. 1973. Small mammals increase on recently cleared and seeded juniper rangeland. *Journal of Range Management* 26:101-103.

Banse, K., and S. Mosher. 1980. Adult body mass and annual production/biomassrelationships of field populations. *Ecological Monographs* 50 (3): 355-379.

Barney, M. A., and N. C. Frischknecht. 1974. Vegetation changes following fire in the pinyon-juniper type of west-central Utah. *Journal of Range Management* 27 (2): 91-96.

Barrett, S. W. 1988. Fire suppression's effects on forest succession within a central Idaho wilderness. 3:76-80. *Western Journal of American Forestry.*

REFERENCES

Barro, S. C., and S. G. Conard. 1987. Use of ryegrass seeding as an emergency revegetation measure in chaparral ecosystems. General Technical Report PSW-102. Berkeley, CA: United States Department of Agriculture, Forest Service, Pacific Southwest Research Station.

Barry, J. W., R. B. Ekblad, P. A. Kenney, and L. A. Barber. 1983. Drift from aerial application to coniferous seed orchards. American Society of Agriculture Engineers paper no. AA-83-003.

Bartel, L. E., and L. R. Rittenhouse. 1979. Herbicidal control of Gambel oak root sprouts in southwestern Colorado. *Down to Earth* 36:6-9.

Barthel, E. 1981. Increased risk of lung cancer in pesticide-exposed male agricultural workers. *Journal of Toxicology and Environmental Health* 8:1027-1040.

Basrur, S. V., R. A. Fletcher, and R. K. Basrur. 1976. In vitro effects of 2,4-dichlorophenoxyacetic acid (2,4-D) on bovine cells. *Canadian Journal of Comparative Medicine*. 40:408-412.

Baur, J. K. 1976. Effects of picloram and tebuthiuron on establishment of rye grass winter pasture. *Journal of Range Management* 31:450-455.

Baur, J. R., R. W. Bovey, and M. G. Merkle. 1972. Concentration of picloram in runoff water. *Weed Science* 20:309-313.

Bayless, S. R. 1969. Winter food habits, range use, and home range of antelope in Montana. *Journal of Wildlife Management* 33:538-551.

Beaton, J. D. 1959. The influence of burning on the soil in the timber range area of Las Lejuene, British Columbia. I-II. *Canadian Journal of Soil Science* 39 (1): 1-11.

Beck, L. S., D. I. Hepler, and K. L. Hansen. 1982. The acute toxicology of selected petroleum hydrocarbons. In Proceedings of the symposium . . . the toxicity of petroleum hydrocarbons, ed. H. N. MacFarland, C. E. Holdsworth, J. A. MacGregor, R. W. Call, and M. L. Kane. Washington, DC: American Petroleum Institute.

Beck, R. F., and D. A. Tober. 1985. Vegetation changes on creosote bush sites after removal of shrubs, cattle and rabbits. Bulletin 717. Las Cruces, NM: New Mexico State University, Agricultural Experiment Station.

Bedunah, E. D. J., and R. E. Sosebee. 1985. Influence of site manipulation on infiltration rates of a depleted west Texas range site. *Journal of Range Management* 38:200-205.

Behnke, R. J. 1979. The Native Trout of the Genus Salmo of Western North America. Monograph by US Forest Service, Fish and Wildlife Service and BLM.

Belles, R. P., and F. J. Mecler. 1982. Inhalation teratology of jet fuel A, fuel oil, and petroleum naphtha in rats. In Proceedings of the symposium . . . the toxicology of petroleum hydrocarbons, ed. MacFarland, H. N., C. E. Holdsworth, J. A. MacGregor, R. W. Call, and M. L. Kane. Washington, DC: American Petroleum Institute.

Benson, L., and R. A. Darrow. 1981. *Trees and shrubs of the southwestern deserts*. 3rd ed. University of Arizona Press, Tucson, AZ.

Bentner, E. L., and D. Anderson. 1943. The effect of surface mulches on water conservation and forage production in some semi-desert soils. *Journal of American Society of Agronomy* 35:393-400.

Berkley, M. C. and K. R. Magee. 1963. Neuropathy following exposure to a demethylamine salt of 2,4-D. *Archives of Internal Medicine* 111:351-352.

Best, L. B. 1972. First-year effects of sagebrush control on two sparrows. *Journal of Wildlife Management* 36:534-544.

Bingham, E., R. P. Trosset, and D. Warshawsky. 1979. Carcinogenic potential of petroleum hydrocarbons. *Journal of Environmental Pathology and Toxicology* 3:483-563.

Biodynamics, Inc. Undated. Interim report: A chronic dietary toxicity and oncogenicity study with Ac 243,997 in rats. Project No. 84-2862. East Millstone, NJ.

Bissell, H. D. 1955. The crude protein variations in the browse diet of California deer. *California Fish and Game* 41:145-155.

Blackburn, G. R., R. A. Dietch, C. A. Schreiner, and C. R. Mackerer. 1984. Correlation of in vitro mutagenicity with dermal carcinogenicity for complex, petroleum-derived mixtures. *Environmental Mutagenesis* 6:454.

Blackburn, W. H. 1975. Factors influencing infiltration and sediment production of semiarid rangeland in Nevada. *Water Resources Research* 11:929-937.

Blackburn, W. H., and C. M. Skau. 1974. Infiltration rates and sediment production of selected plant communities in Nevada. *Journal of Range Management* 27:476-480.

Blackburn, W. H., and P. T. Tueller. 1970. Pinyon and juniper invasion in black sagebrush communities in east central Nevada. *Ecology* 51:841-848.

Blackburn, W. W. 1983. Influence of brush control on hydrologic characteristics of range watersheds. In Proceedings of brush management symposium, ed. K. C. McDaniel. 73-78. Denver, CO: Society for Range Management.

Blair, A. 1982. Cancer risks associated with agriculture: Epidemiologic evidence. In *Genetic Toxicology*, eds. R. Fleck and A. Hollaender. New York: Plenum Publishing Corporation.

Blair, A., D. Grauman, J. Lubin, and J. Fraumeni. 1983. Lung cancer and other causes of death among licensed pesticide applicators. *Journal of the National Cancer Institute* 71 (1): 31-37.

Blair, A., H. Walker, K. Cantor, L. Burmeister, and K. Wiklund. 1985. Cancer among farmers. *Scandinavian Journal of Work Environmental Health* 11:397-407.

Blair, A., and D. White. 1981. Death certificate study among farmers in Wisconsin. *Journal of the National Cancer Institute* 66 (6): 1027-1030.

Blair, A., and D. White. 1985. Leukemia cell types and agricultural practices in Nebraska. *Archives of Environmental Health* 40 (4): 211-214.

Blair, A., and T. Thomas. 1979. Leukemia among Nebraska Farmers: A death certificate study. *American Journal of Epidemiology* 110 (3): 264-273.

Blaisdell, J. P. 1953. Ecological effects of planned burning of sagebrush-grass range on the upper Snake River Plains. Technical Bulletin 1075. Washington, DC: U.S. Department of Agriculture.

Blaisdell, J. P., and R. C. Holmgren. 1984. Managing intermountain rangelands—salt desert shrub ranges. General Technical Report INT-163. U.S. Department of Agriculture, Forest Service, Intermountain Research Station.

Blaisdell, J. P., and W. F. Mueggler. 1956. Effect of 2,4-D on forbs and shrubs associated with big sagebrush. *Journal of Range Management* 9:38-40.

Blaisdell, J. P., R. B. Murray, and E. D. McArthur. 1982. Managing intermountain rangelands—sagebrush-grass ranges. General Technical Report INT-134. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Station.

REFERENCES

Blakley, B. R. 1986a. The effect of oral exposure to the n-butylester of 2,4-dichlorophenoxyacetic acid on the immune response in mice. International Journal of Immunopharmacology 8 (1): 93-99.

Blakley, B. R. and P. M. Blakley. 1986b. The effect of prenatal exposure to the n-butylester of 2,4-dichlorophenoxyacetic acid (2,4-D) on the immune response of mice. *Teratology* 33 (1): 15-20.

Blakley, B. R. and B. H. Schiefer. 1986c. The effect of topically applied n-butylester of 2,4-dichlorophenoxyacetic acid on the immune response in mice. *Journal of Applied Toxicology* 6 (4): 291-295.

Bleak, A. T., N. C. Frischknecht, A. D. Plummer, and R. E. Eckert, Jr. 1965. Problems in artificial and natural revegetation of the arid shadscale vegetation zone of Utah and Nevada. *Journal of Range Management* 18:59-65.

Bock, C. E., and J. H. Bock. 1978. Response of birds, small mammals, and vegetation to burning sacaton (Sporobolus wrightii) grasslands in southeastern Arizona (Wildfires). *Journal of Range Management* 31 (4).

Bock, C. E., J. H. Bock, K. L. Jepson, and J. C. Ortega. 1986. Ecological effects of planting African levegrasses in Arizona. *National Geographic Research* 2:456-463.

Borror, D. J., and R. E. White. 1970. A field guide to the insects of America north of Mexico. *Peterson Field Guide series.* Boston: Houghton Mifflin Co.

Boschung, H. T., Jr., J. D. Williams, D. W. Gotshall, D. K Caldwell, and M. C. Caldwell. 1983. The Audubon Society field guide to North American fishes, whales, and dolphins. New York: Alfred A. Knopf, Inc.

Bovey, R. W. 1964. Aerial applications of herbicides for the control of sand sagebrush. *Journal of Range Management* 17:194-196.

Bovey, R. W., F. S. Davis, and M. G. Merkle. 1967. Distribution of picloram in huisache after foliar and soil applications. *Weeds* 15:245-249.

Bowes, G., and E. S. Molberg. 1975. Picloram for the control of leafy spurge. *Canadian Journal of Plant Science* 55:1023-1027.

Bowns, J E., personal communication dated May 22, 1990.

Box, T. W., J. Powell, and D. L. Drawe. 1967. Influence of fire on south Texas chaparral communities. *Ecology* 48:955-961.

Brackley, G. K. 1987. SCS inventory and classification procedures, p. 231-235. IN Proc. Pinyon-Juniper Conference. USDA Forest Service. Gen. Tech. Rep. INT-215. Intermountain Research Station. Ogden, Utah.

Bradley, A. 1986a. Chrysothamnus nauseosus. In Fire effects information system (data base), comp. William C. Fischer. Missoula, MT: United States Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory.

Bradley, A. 1986b. *Chrysothamnus viscidiflorus.*

Bradley, A. 1986c. *Festuca idahoensis.*

Bradley, A. 1986d. *Poa secunda.*

Bradley, A. 1986e. *Pseudoroegneria spicata.*

Bradley, A. 1986f. *Purshia tridentata.*

Bradley, A. F. 1984. Rhizome morphology, soil distribution, and the potential fire survival of eight woody understory species in western Montana. M. A. thesis, Department of Botany, University of Montana, Missoula, MT.

Brady, N. C. 1974. *The nature and property of soils.* 8th ed. New York: MacMillan Publishing.

Branson, F. A. 1985. Vegetation changes on western rangelands. Denver, CO: Society for Range Management.

Branson, F. A., G. F. Gifford, K. G. Renard, and R. F. Hadley. 1981. Rangeland hydrology. 2d ed. Denver, CO: Society for Range Management.

Branson, F. A., R. F. Miller, and I. S. McQueen. 1966. Contour furrowing, pitting, and ripping on rangelands in the western United States. *Journal of Range Management* 19:182-190.

Braun, C. E., T. Britt, and R. O. Wallestad. 1977a. Guidelines for maintenance of sage grouse habitats. *Wildlife Society Bulletin* 5:99-106.

Braun, R., J. Schoneich, and D. Ziebarth. 1977b. In vivo formation of N-nitroso compounds and detection of their mutagenic activity in the host-mediated assay. *Cancer Research* 37:4572-4579.

Bridges, B. A., and M. L. Mendelsohn. 1986. Genetic toxicology of environmental chemicals, part B: Genetic effects and applied mutagenesis. New York: Alan R. Liss, Inc.

Brinson, M. M., B. L. Swift, R. C. Plantico, and J. S. Barclay. 1981. Riparian ecosystems: Their ecology and status. U.S. Department of the Interior, Fish and Wildlife Service, Biological Services publication FWS/OBS-81/17.

Britton, C. M., and M. H. Ralphs. 1978. Use of fire as a management tool in sagebrush ecosystems. In The sagebrush ecosystem: A synopsis, 101-109. Utah State University.

Britton, C. M., and F. A. Sneva. 1983a. Big sagebrush control with tebuthiuron. *Journal of Range Management* 36:707-708.

Britton, C. M. and H. A. Wright. 1983b. Brush management with fire. In Proceedings of the brush management symposium, ed. K. C. McDaniel, 61-68. Denver, CO: Society for Range Management.

Brock, J. H., W. H. Blackburn, and R. H. Haas. 1982. Infiltration and sediment production on a deep hardland range site in north central Texas. *Journal of Range Management* 35:195-198.

Brockman, C. F. 1968. *Trees of North America.* New York: Golden Press.

Brown, A. A., and K. P. Davis. 1973. *Forest fire: control and use.* New York: McGraw-Hill Book Company.

Brown, D. E., ed. 1982. Desert plants. Vol. 4. University of Arizona, Tucson, AZ, for the Boyce Thompson Southwestern Arboretum.

Brown, J. C., R. A. Evans, and J. A. Young. 1985. Effects of sagebrush control methods and seeding on runoff and erosion. *Journal of Range Management* 38:195-199.

Brown, J. K., and D. G. Simmerman. 1986. Appraising fuels and flammability in western aspen: A prescribed fire guide. General Technical Report INT-205. Ogden, UT: United States Department of Agriculture, Forest Service, Intermountain Research Station.

Brown, L. 1985. *Grasslands: The Audubon Society nature guides.* New York: Alfred A. Knopf.

REFERENCES

Bruner, A. D., and D. A. Klebenow. 1978. A technique to burn pinyon-juniper woodlands in Nevada. General Technical Report INT-219. Ogden, UT: United States Department of Agriculture, Forest Service, Intermountain Research Station.

Brusick, D. 1987. *Principles of genetic toxicology*. 2d ed. New York: Plenum Press.

Brusick, D. J., J. Ashby, F. deSerres, P. Lohman, T. Matsushima, B. Matter, M. Mendelsohn, and M. Waters. 1986. Weight of evidence scheme for evaluation and interpretation of short-term results. In Genetic toxicology of environmental chemicals, part B: Genetic effects and applied mutagenesis. New York: Alan R. Liss, Inc.

Bucher, Robert R. 1984. The potential cost of spotted knapweed to Montana range users. Cooperative Extension Service Bulletin 1316. Bozeman: Montana State University.

Buckhouse, J. C. 1985. Effects of fires on rangeland watersheds. In Rangeland fire effects; A symposium, 58-60. Boise, ID: Bureau of Land Management.

Buckhouse, J. C., and G. F. Gifford. 1976a. Sediment production and infiltration rates as affected by grazing and debris burning on chained and seeded pinyon-juniper. *Journal of Range Management* 29:83-84.

Buckhouse, J. C., and G. F. Gifford. 1976b. Grazing and debris burning on pinyon-juniper sites—some chemical water quality implications. *Journal of Range Management* 29:299-301.

Buffington, L. C., and C. H. Herbel. 1965. Vegetation changes on a semidesert grassland range from 1858 to 1963. *Ecological Monographs* 35:139-164.

Bureau of National Affairs, Inc., 1989. Air pollution control. BNA Policy and Practice Series, no. 108 (February 1989). Washington, DC.

Burkhardt, J. W., and E. W. Tisdale. 1976. Causes of juniper invasion in southwestern Idaho. *Ecology* 57 (3): 472-484.

Burks, S. L. 1982. Effects of oil on aquatic organisms: A review of selected literature. Prepared for the American Petroleum Institute, Washington, DC.

Burt, W. H. 1952. A field guide to the mammals. Boston: Houghton Mifflin Co.

Burt, W. H., and R. P. Grossenhelder. 1966. A field guide to the mammals. Boston: Houghton Mifflin.

Cable, D. R. 1965. Damage to mesquite, Lehmann lovegrass and black grama by a hot June fire. *Journal of Range Management* 18:326-328.

Cable, D. R. 1975. Range management in the chaparral type and its ecological basis: The status of our knowledge. Research Paper RM-155. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Station.

Cable, D. R. 1976. Twenty years of changes in grass production following mesquite control and reseeding. *Journal of Range Management* 29:286-289.

Calabrese, E. J. 1978. *Pollutants and high risk groups*. New York: John Wiley and Sons Inc.

Calabrese, E. J. 1983. *Principles of animal extrapolation*. New York: John Wiley and Sons.

Calabrese, E. J. 1985. Uncertainty factors and interindividual variation. *Regulatory Toxicology and Pharmacology* 5:190-196.

Calabrese, E. J., and M. W. Dorsey. 1984. *Healthy living in an unhealthy world*. New York: Simon and Schuster.

California Department of Food and Agriculture. 1988. Summary of toxicological data for amitrole.

California Department of Food and Agriculture. 1986. Summary of toxicological data for atrazine.

California Department of Food and Agriculture. 1986. Summary of toxicological data for bromacil.

California Department of Food and Agriculture. 1986. Summary of toxicological data on picloram.

Call, M. W. 1974. Habitat requirements and management recommendations for sage grouse. U.S. Department of the Interior, BLM Technical note 1220-5.

Call, M. W., and C. Maser. 1985. Wildlife Habitats in Managed Rangelands - The Great Basin of Southeastern Oregon. Sage Grouse. Gen. Tech. Report PNW-187. USDA. Pacific Northwest Forest and Range Exp. Station. US Forest Service.

Callison, J., J. D. Brotherson, and J. E. Bowns. 1985. The effects of fire on the blackbrush (Coleogyne ramosissima) community of southwestern Utah. *Journal of Range Management* 38:535-538.

Cambell, R. E., M. B. Baker, P. F. Ffolliott, F. R. Larson, and C. C. Avery. 1977. Wildfire effects on a ponderosa pine ecosystem: An Arizona case study. Research Paper RM-191. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Canadian Centre for Toxicology. 1987. Expert panel report on carcinogenicity of 2,4-D. March 23, 1987. Guelph, Ontario, Canada.

Canfield, R. H. 1939. The effect of intensity and frequency of clipping on density and yield of black grama and tobosa grass. Technical Bulletin 681. Washington, DC: U.S. Department of Agriculture.

Canode, C. L., W. C. Robocker, and T. J. Muzik. 1962. Grass seed production as influenced by chemical control of downy brume. *Weeds* 10:216-219.

Cantor, K., 1982. Farming and mortality from non-Hodgkin's lymphoma: A case-control study. International Journal of Cancer 29:239-247.

Cantor, K., and A. Blair. 1984. Farming and mortality from multiple myeloma: A case-control study with the use of death certificates. *Journal of the National Cancer Institute* 72 (2): 251-255.

Cantor, K., G. Everett, A. Blair, R. Gibson, L. Schuman, and P. Isocson. 1985. Farming and non-Hodgkin's lymphoma. *American Journal of Epidemiology* 122:535.

Carsel, R.F., C.N. Smith, L.A. Mulkey, J.D. Dean, and P. Jowise. 1984. Users manual for the pesticide root zone model (PRZM). Environmental Protection Agency, EPA-600/3-84-109.

Carter, C. O. 1977. The relative contribution of mutant genes and chromosome abnormalities to genetic ill-health in man. In Progress in genetic toxicology. Vol. 2., ed. D. Scott, B. A. Bridges, and F. H. Sobels. Amsterdam: Elsevier/North Holland.

Cary, J. W., and D. D. Evans, eds. 1974. Soil crusts. Technical Bulletin 214. Tucson, AZ: University of Arizona, University of Arizona Agricultural Experiment Station.

Castrale, J. S. 1982. Effects of two sagebrush control methods on nongame birds. *Journal of Wildlife Management* 46:945-952.

REFERENCES

Charley, J. L., and N. E. West. 1975. Plant-induced soil chemical patterns in some shrub-dominated semidesert ecosystems of Utah. *Journal of Ecology* 63:945-964.

Chase, A. 1971. *Manual of the grasses of the United States*. 2 vols. New York: Dover Publications Inc.

Chase, Richard. 1985. Crop losses caused by weeds in Idaho. Pacific Northwest Weed Topics, Volume 85-1. January 15, 1985.

Christensen, N. L., and C. H. Muller. 1975. Effects of fire on factors controlling plant growth in Adenostoma chaparral. *Ecological Monographs* 45:29-55.

Chrosciewicz, Z. 1986. Foliar moisture content variations in four coniferous tree species of central Alberta. *Canadian Journal of Forest Research* 16:157-162.

Chu, M. M., and D. Kamely. 1988. Environmental cancer and biotechnology. In Biotechnology. Vol. 6. June 1988.

Clark, B. 1989. Personal communication.

Clark, D. E., C. E. Coppock, G. W. Iure. 1981. Residues of the plant growth regulator mefluidide [N-[2,4-Dimethyl-5-[[(trifluoromethyl)sulfonyl]amino] phenyl]acetamide] in the milk and tissues of lactating dairy cows: A 28-day feeding study. *Journal of Agricultural Food Chemistry* 29:1175-1179.

Clark, J. S. 1989. The forest is for burning. *Natural History. January (1): 50-53.*

Clary, W. P. 1971. Effects of Utah juniper removal on herbage yields from Springerville soils. *Journal of Range Management* 24:373-378.

Clary, W. P. 1974. Response of herbaceous vegetation to felling of alligator juniper. *Journal of Range Management* 27:387-389.

Clary, W. P., M. B. Baker, Jr., P. F. O'Connell, T. N. Johnsen, Jr., and R. E. Campbell. 1974. Effects of pinyon-juniper removal on natural resource products and uses in Arizona. Research Paper RM-128. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Station.

Clary, W. P., S. Goodrich, and B. M. Smith. 1985. Response of tebuthiuron by Utah juniper and mountain big sagebrush communities. *Journal of Range Management* 38:56-60.

Clary, W. P., and D. A. Jameson. 1981. Herbage production following tree and shrub removal in the pinyon-juniper type of Arizona. *Journal of Range Management* 34:109-113.

Clary, W. P., and D. C. Morrison. 1973. Large alligator junipers benefit early-spring forage. *Journal of Range Management* 26:70-71.

Cluff, G. J., J. A. Young, and R. A. Evans. 1983. Edaphic factors influencing the control of Wyoming big sagebrush and seedling establishment of crested wheatgrass. *Journal of Range Management* 36:786-792.

Coffelt, M. A., and P. B. Schultz. 1988. Influence of plant growth regulators on the development of the azalea lace bug (Hemiptera: Tingidae). *Journal of Economic Entomology* 81 (1): 290-292.

Collings, M. R., and R. M. Myrick. 1966. Effects of juniper and pinyon eradication on stream flow from Corduroy Creek Basin, AZ. U.S. Geological Survey Professional Paper 149-B.

Colton, T. 1986. Herbicide exposure and cancer-editorial. *Journal of the American Medical Association* 256 (9): 1176-1178.

Combs, E. 1990. Biological Control of Weeds, Status Report, 1990. Oregon Department of Agriculture.

Conant, R. 1958. A field guide to reptiles and amphibians of the United States and Canada east of the 100th meridian. Boston: Houghton Mifflin Co.

Conaway, C. C., C. A. Schreiner, and S. T. Cragg. 1982. Mutagenicity evaluation of petroleum hydrocarbons. In: Symposium proceedings, ed. H. N. MacFarland, C. E. Holdsworth, J. A. MacGregor, R. W. Call, and M. L. Kane. Washington, DC: American Petroleum Institute.

Connell, D. W., and G. J. Miller. 1984. *Chemistry and ecotoxicology of pollution*. New York: John Wiley and Sons.

Cook, C. W. 1966a. Carbohydrate reserves in plants. Resources Series #31. Utah Agricultural Experiment Station.

Cook, C. W. 1966b. The role of carbohydrate reserves in managing range plants. Mimeo Series 499. Utah Agricultural Experiment Station.

Cooperrider, A. Y., R. J. Boyd, and H. R. Stuart, eds. 1986. Inventory and monitoring of wildlife habitat. Vol. xviii. Denver, CO: U.S. Department of the Interior, Bureau of Land Management Service Center.

Cox, J. R., and G. C. Jordan. 1983. Density and production of seeded range grasses in southeastern Arizona (1970-1982). *Journal of Range Management* 36:649-652.

Cox, J. R., R., M. H. Martin, F. A. Ibarra F., and H. L. Morton. 1986. Establishment of range grasses on various seedbeds at creosotebush (Larrea tridentata) sites in Arizona, U.S.A., and Chihuahua, Mexico. *Journal of Range Management* 34:540-546.

Cox, J. R., H. L. Morton, T. N. Johnsen, Jr., G. L. Jordan, S. C. Martin, and L. C. Fleo. 1982. Vegetation restoration in the Chihuahuan and Sonoran Deserts of North America. ARM-W-28. U.S. Department of Agriculture, Agriculture Resource Service.

Cronquist, A., A. H. Holmgren, N. H. Holmgren, and J. L. Reveal. 1972. *Intermountain flora*. Vol. 1. New York: Hafner Publishing Co., Inc.

Crouch, G. L. 1974. Interaction of deer and forest succession on clear cuttings in the coast range of Oregon. Wildlife and Forest Management in the Pacific Northwest. 133-148. Corvallis, OR: Oregon State University.

Crump, K. S. 1983. Statement as expert witness in the case of Northwest Coalition for Alternatives to Pesticides (NCAP) et al. v. J. R. Block et al. Civil case 83-6273-E, U.S. District Court for the District of Oregon.

Damuth, J. 1981. Home range, home range overlap, and species energy use among herbivorous mammals. *Zoological Journal of the Linnean Society* 15:185-193.

Daubenmire, R. 1970. Steppe vegetation of Washington. Technical Bulletin 62. Washington Agricultural Experiment Station.

Daubenmire, R. 1975. Plant succession on abandoned fields, and fire influences, in a steppe area in southeastern Washington. *Northwest Science* 49 (1): 36-48.

Daubenmire, R. F. 1952. Forest Vegetation of Northern Idaho and adjacent Washington and its bearing on concepts of vegetation classification. *Ecological Monographs* 22:301-330.

Davies, J. E., V. H. Freed, H. F. Enos, R. C. Duncan, A. Barquet, C. Morgade, L. Peters, and J. Danauskas. 1982. Reduction of pesticide exposure with protective clothing for applicators and mixers. *Journal of Occupational Medicine* 24 (6): 464-468.

REFERENCES

Davis, E. A., and P. A. Ingebo. 1973. Picloram movement from a chaparral watershed. *Water Resources Research* 9:1304-1313.

Davis, E. A., and C. P. Pase. 1969. Selective control of brush on chaparral watersheds with soil-applied fenuron and picloram. Research Note RM-140. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Station.

Davis, E. A., and C. P. Pase. 1977. Root system of shrub live oak: Implications for water yield in Arizona chaparral. *Journal of Soil and Water Conservation*. July-August.

Davis, O. K. 1987. Palynological evidence for historic juniper invasion in central Arizona: a late-Quaternary perspective, pp. 120-124. IN Proc. Pinyon-Juniper Conference. USDA Forest Service. Gen. Tech. Rep. INT-215. Intermountain Research Station. Ogden, Utah.

DeBano, L. F., and C. E. Conrad. 1978. The effect of fire on nutrients in a chaparral ecosystem. *Ecology* 59:489-497.

DeBano, L. F., P. H. Dunn, and C. E. Conrad. 1977. Fire's effects on physical and chemical properties of chapparal soils. In Proceedings of the symposium on environmental consequences of fire and fuel management in mediterranean ecosystems, 65-74. Palo Alto, CA.

DeBano, L. F., S. M. Savage, and D. A. Hamilton. 1976. The transfer of heat and hydrophobic substances during burning. *Soil Science Society of America Proceedings*, 40:777-782.

DeByle, N. V. 1985. Management for esthetics and recreation, forage, water, and wildlife. In Aspen: Ecology and Management in the Western United States. General Technical Report RM-119. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

DeByle, N. V., and R. P. Winokur. 1985. Aspen: Ecology and management in the Western United States. General Technical Report RM-119. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Denniston, C. 1982. Low level radiation and genetic risk estimation in man. *Annual Review of Genetics* 16:329-355.

Dick-Peddie, W. A., and J. P. Hubbard. 1977. Classification of riparian vegetation. Importance, preservation and management of riparian vegetation: A symposium. General Technical Report RM-43. U.S. Department of Agriculture, Forest Service.

Dickerson, M. C. 1969. The frog book: *North American toads and frogs*. New York: Dover Publications.

Donahue, R. L., R. W. Miller, and J. C. Shickluna. 1977. *Soils*. 4th ed. Englewood Cliffs, NJ: Prentice-Hall.

Dost, F. N. 1983. An analysis of human health hazards associated with some herbicides used in forestry. Prepared for the Oregon State Office of the Bureau of Land Management. Portland, OR: Bureau of Land Management.

Dost, F. N. 1986. An estimate of carcinogenic risk associated with polyaromatic hydrocarbons in smoke from prescribed burning in forestry. Corvallis, OR: Department of Agriculture, Chemistry, Oregon State University.

Doull, J., C. D. Klaassen, and M. O. Amdur. 1980. *Cassarett and Doull's toxicology*. 2d ed. New York: Macmillan Publishing.

Dow Chemical Company. n.d. Technical information on triclopyr, the active ingredient of Garlon herbicides. Midland, MI: Agricultural Productions Department.

Dow Chemical Company. 1985. Correspondence to Richard J. Nolan, Mammalian and Environmental Toxicology Research Laboratory, to Larry Gross, U.S. Forest Service, regarding triclopyr toxicology data. October 22, 1985.

Dow Chemical Company. 1987. Supplement information concerning triclopyr and picloram (with additional 2,4-D comments) for use in development of a vegetation management environmental impact statement for the southern region. Submitted to U.S. Forest Service and Labat-Anderson Incorporated. Midland, MI: Dow Chemical Company.

Draper, W. M., and J. C. Street. 1982. Application exposure to 2,4-D, dicamba, and a dicamba isomer. *Journal of Environmental Sciences and Health* B17 (4): 321-339.

Drozdz, A. 1968. Digestibility and assimilation of natural foods in small rodents. *Acta Theriologica* 13 (21): 367-389.

Du Pont Chemical Company. 1982. Technical data sheet for chlorsulfuron. Wilmington, DE: Biochemicals Department.

Du Pont Chemical Company. 1983. Technical data sheet for sulfometuron methyl. Wilmington, DE: Agricultural Chemicals Department.

Du Pont Chemical Company. 1984a. Technical data sheet for hexazinone. Wilmington, DE: Agricultural Chemicals Department.

Du Pont Chemical Company. 1984b. Technical data sheet for metsulfuron methyl. Wilmington, DE: Biochemicals Department.

Du Pont Chemical Company. 1986. Material safety data sheet for Oust herbicide. Wilmington, DE: Agricultural Products Department.

Du Pont Chemical Company. 1987. Product information for Krenite™, Oust™, and Velpar™. Wilmington, DE.

Dunn, P. H., and L. F. DeBano. 1977. Fire's effect on biological and chemical properties of chaparral soils. In Symposium on the environmental consequences of fire and fuel management in Mediterranean ecosystems, 75-84. Palo Alto, CA.

Dwyer, D. B. 1972. Burning and nitrogen fertilization of tobosa grass. Bulletin 595. Las Cruces, NM: New Mexico State University Agricultural Experiment Station.

Dwyer, D. D., J. C. Buckhouse, and W. S. Huey. 1984. Impacts of grazing intensity and specialized grazing systems on the use and value of rangeland. In Summary and recommendations for developing strategies for rangeland management: A report prepared by the committee on developing strategies for rangeland management, 867-884. Natural Resource Council/National Academy of Science.

Dwyer, D. D., and R. D. Pieper. 1967. Fire effects on blue grama-pinyon-juniper rangeland in New Mexico. *Journal of Range Management* 20:359-362.

Dyrness, C. T., and A. Norum. 1983. The effects of experimental fires on black spruce forest floors in interior Alaska. *Canadian Journal of Forest Research* 13 (5): 879-893.

Eaton, B. J., D. G. Wilson, and W. L. Kurtz. 1978. Tolerance of several forage grasses to tebuthiuron. *Society for Range Management Abstracts of Papers* 31:56.

Eckert, R. E., Jr. 1975. Improvement of mountain meadows in Nevada. Research Report. U.S. Department of the Interior, Bureau of Land Management.

Eckert, R. E., Jr., A. D. Bruner, G. J. Klomp, and F. F. Peterson. 1973a. Mountain meadow improvement through seeding. *Journal of Range Management* 26:200-203.

REFERENCES

Eckert, R. E., Jr., A. D. Bruner, G. J. Klomp, and F. F. Peterson. 1973b. Control of Rocky Mountain iris and vegetation response on mountain meadows. *Journal of Range Management* 26:352-355.

Eckert, R. E., Jr., M. K. Wood, W. H. Blackburn, and F. F. Peterson. 1979. Impacts of off-road vehicles on infiltration and sediment production of two desert soils. *Journal of Range Management* 32:394-397.

Eddleman, L. E. 1987. Establishment and stand development of western juniper in central Oregon, pp. 255-259. IN Proc. Pinyon-Juniper Conference. USDA Forest Service. Gen. Tech. Rep. INT-215. Intermountain Research Station. Ogden, Utah.

Eddy, S. 1957. *The Freshwater Fishes. Dubuque, Iowa.* Wm. C. Brown Co.

Ehling, U. H. 1988. Quantification of the genetic risk of environmental mutagens. *Risk Analysis* 8:45-57.

Eriksson, M. L., L. Hardell, N. O. Berg, T. Moller, and O. Axelson. 1981. Soft tissue sarcomas and exposure to chemical substances: Case referent study. *British Journal of Industrial Medicine* 38:27-33.

Erne, K. 1974. Phenoxy herbicide residues in Swedish fish and wildlife. In *Pesticides environmental quality and safety.* Vol. III, supplement, ed. F. Coulston, F. Korte, F. Klein, and I. Rosenblum. Stuttgart, West Germany: Georg Thieml Publishers.

Evans, R. A. 1988. Management of pinyon-juniper woodlands. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. General Technical Report INT-249.

Evans, R. A., R. E. Eckert, Jr., and J. A. Young. 1975. The role of herbicides in management of pinyon-juniper woodlands. In The pinyon-juniper ecosystem: A symposium. Logan, UT: Utah State University.

Evans, R. A., R. E. Eckert, Jr., and J. A. Young. 1986. High technology weed control-revegetation systems for establishment and maintenance of crested wheatgrass. In Crested wheatgrass: Its values, problems and myths; symposium proceedings, ed. K. L. Johnson, 91-96. Logan, UT: Utah State University.

Evans, R. A., J. A. Young, and R. E. Eckert, Jr. 1969a. Herbaceous weed control and revegetation of semi-arid and rangelands in western United States. *Outlook on Agriculture* 6:60-66.

Evans, R. A., R. E. Eckert, Jr., B. L. Kay, and J. A. Young. 1969b. Downy brome control by soil active herbicides for revegetation on rangelands. *Weed Science* 17:166-169.

Evans, R. A., and J. A. Young. 1985. Plant succession following control of western juniper (Juniperus occidentalis) with picloram. *Weed Science* 33:63-68.

Evans, R. A., J. A. Young, and R. E. Eckert, Jr. 1979. Use of herbicides as a management tool. In The sagebrush ecosystem: A symposium, 110-116. Logan, UT: Utah State University.

Everett, R. L. 1987a. Allelopathic effects on pinyon and juniper litter on emergence and growth of herbaceous species. In Proceedings of symposium: Seed and seedbed ecology of rangeland plants, ed. G. W. Frasier, and R. A. Evans, 62-67. April 21-23, 1987. Tucson, AZ: U.S. Department of Agriculture, Agricultural Reserve Service.

Everett, R. L. 1987b. Plant response to fire in the pinyon-juniper zone. In Proceedings—Pinyon-juniper conference, 152-157. General Technical Report INT-215. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station.

Everett, R., and W. Clary. 1985. Fire effects and revegetation on juniper-pinyon woodlands. In Rangeland fire effects; A symposium, 33-37. Boise, ID: Bureau of Land Management.

Fagerstone, K. A., H. P. Tietjen, and G. K. LaVoie. 1977. Effects of range treatment with 2,4-D on prairie dog diet. *Journal of Range Management* 30:57-60.

Feldman, R. J., and H. I. Maibach. 1974. Percutaneous penetration of some pesticides and herbicides in man. *Toxicology and Applied Pharmacology* 28:126-132.

Ffolliott, P. F., and D. B. Thorud. 1975. Water yield improvement by vegetation management: Focus on Arizona. PB-246-055 U.S. Department of Agriculture, Forest Service, National Technical Information Service.

Fisher, H. L., B. Most, and L. L. Hall. 1985. Dermal absorption of pesticides calculated by deconvolution. *Journal of Applied Toxicology* 5 (3): 163-177.

Fisser, H. G. 1968. Soil moisture and temperature changes following sagebrush control. *Journal of Range Management* 21:283-287.

Flinn, M. A., and R. W. Wein. 1977. Depth of underground plant organs and theoretical survival during fire. *Canadian Journal of Botany* 55:2550-2554.

Folmar, L. C., H. O. Sanders, and A. M. Julin. 1979. Toxicity of the herbicide glyphosate and several of its formulations to fish and aquatic invertebrates. *Archives of Environmental Contamination and Toxicology* 8:269-278.

Forcella, Frank and Stephen J. Harvey. 1981. *New and exotic weeds of Montana.* Vol. II: Migration and distribution of 100 alien weeds in Northwestern USA, 1880-1980. Helena: Montana Department of Agriculture.

Fowells, H. A., and R. E. Stephenson. 1933. Effect of burning on forest soils. *Soil Science* 38:175-181.

Frandsen, W. H. and K. C. Ryan. 1986. Soil moisture reduces belowground heat flux and soil temperatures under a burning fuel pile. *Canadian Journal of Forest Research* 16:244-248.

Franklin, C. A., R. Grover, J. W. Markham, A. E. Smith, and K. Yashida. 1982. Effect of various factors on workers involved in aerial spraying of herbicides. *Transactions of the Canadian Journal of Industrial Hygiene* 43:97-177.

French, R. A. 1984. Extension education program relative to weeds in Missoula county. In Proceedings of the Knapweed Symposium. Bulletin 1315. Bozeman: Montana State University, Plant and Soil Science Department and Cooperative Extension Service.

French, R. A. and J. R. Lacey. 1983. Knapweed: Its cause, effect and spread in Montana. Cooperative Extension Service Circular 307. Bozeman: Montana State University.

Frisina, M. R. and F G. Morin. 1989. Grazing Private and Public Land to Improve the Fleecer Elk Winter Range. U.S. Forest Service, Butte, MT.

Froehlich, H. A. 1973. The impact of even-age forest management on physical properties of soils. Paper 848:199-220. Corvallis, OR: Oregon State University, School of Forestry.

Fuller, W. H., S. Shannon, and P. S. Burgess. 1955. Effect of burning on certain forest soils of Northern Arizona. *Forest Science* 1:44-50.

Gallagher, A., and W. H. Vanden Born. 1976. Tolerance of creeping red fescue and timothy to herbicides used to control Canada thistle. *Canadian Journal of Plant Science* 56:331-338.

REFERENCES

Garrison, G. A., A. J. Bjugstad, D. A. Duncan, M. E. Lewis, and D. R. Smith. 1977. Vegetation and environmental features of forest and range ecosystems. Agriculture Handbook no. 475. U.S. Department of Agriculture, Forest Service.

Gebel, H.S. 1987. Roswell District Brush Control Results and Recommendations. USDI, BLM.

Germano, D. J. 1978. Response of selected wildlife to mesquite removal in desert grassland. Master's thesis, University of Arizona, Tucson.

Germano, D. J., R. Hungerford, and S. C. Martin. 1983. Responses of selected wildlife species to the removal of mesquite from desert grassland. *Journal of Range Management* 36:309-311.

Gersich, F. M., D. L. Hopkins, and D. P. Milazzo. 1985. Acute and chronic toxicity of technical picloram (4-amino-3,5,6-trichloropicolinic acid) to Daphnia magna Straus. *Bulletin of Environmental Contamination and Toxicology* 35:121-126.

Gesink, R. W., H. P. Alley, and G. A. Lee. 1973. Vegetative response to chemical control of broom snakeweed on a blue grama range. *Journal of Range Management* 26:139-143.

Ghassemi, M., L. Fargo, Page Painter, Pam Painter, S. Quinlivan, R. Scofield, and A. Takata. 1981. Environmental fates and impacts of major forest use pesticides. Prepared for U.S. EPA, Office of Pesticides and Toxic Substances. Redondo Beach, CA: TRW Environmental Division.

Gibbens, R. P., C. H. Herbel, and J. M. Lenz. 1987. Field-scale tebuthiuron application on brush-infested rangeland. *Weed Technology* 1:323-327.

Gifford, G. F. 1968. Influence of various rangeland cultural treatments on runoff, sediment production, and soil moisture patterns in the big sagebrush type East Gate Basin, Nevada. Ph.D. diss., Utah State University, Logan.

Gifford, G. F. 1972. Infiltration rates and sediment production trends on a plowed big sagebrush site. *Journal of Range Management* 25:53-55.

Gifford, G. F. 1975. Impacts of pinyon-juniper manipulation on watershed values. In The pinyon-juniper ecosystem: A symposium, 127-140. Logan, UT: Utah State University.

Gifford, G. F. 1981. Impact of burning pinyon-juniper debris on select soil properties. *Journal of Range Management* 34:357-359.

Gifford, G. F. 1982. A long-term infiltrometer study in southern Idaho. *Journal of Hydrology* 58:367-374.

Gifford, G. F., G. Williams, and G. G. Coltharp. 1970. Infiltration and erosion studies on pinyon-juniper conversion sites in southern Utah. *Journal of Range Management* 23:402-406.

Gleason, H. A., and A. Cronquist. 1963. Manual of vascular plants of northeastern United States and adjacent Canada. Princeton, NJ: D. Van Nostrand Co., Inc.

Glenn, B. P., J. Bond, S. Glenn. 1987. Effects of mefluidide treatment, nitrogen fertilization and tall fescue variety on nutrient metabolism by growing sheep fed fall-harvested slages. *Journal of Animal Science* 65:797-807.

Goldstein, N. P., P. H. Jones, and J. R. Brown. 1959. Peripheral neuropathy after exposure to an ester of dichlorophenoxyacetic acid. *Journal of the American Medical Association* 171:1306-1309.

Gordon, M. S., G. A. Bartholomew, A. D. Grinnell, C. B. Jorgensen, and F. N. White. 1968. *Animal function: Principles and adaptations*. New York: Macmillan Company.

Goss, D. 1988. Pesticide-soil interaction: Potentials for loss. In: Integrating water quality and quantity into conservation planning. Soil Conservation Service and Cooperative Extension Service Joint Water Quality Workshops. October-Novermber, 1988.

Green, L. M. 1986. Mortality analysis of Ontario Hydro forestry tradesmen, cohort 1950-1982: Executive summary. Health Services Department, Health and Safety Division. Toronto, Ontario: Ontario Hydro.

Greenhalgh, R. 1978. IUPAC Commission on Terminal Pesticides. *Journal of the Association of Official Agricultural Chemists*. 64 (4): 841-868.

Griffith, L. W., G. E. Schuman, F. Rauzi, and R. E. Baumgartner. 1985. Mechanical renovation of shortgrass prairie for increased herbage production. *Journal of Range Management* 38:7-10.

Grissom, R. E., Jr., C. Brownie, and F. E. Guthrie. 1985. Dermal absorption of pesticides in mice. *Pesticide Biochemistry and Physiology* 24:119-123.

Gruell, G. E. 1983. Fire and vegetative trends in the northern Rockies: interpretations from 1871-1982 photographs. USDA Forest Service. Gen. Tech. Rep. INT-158. Intermountain Research Station. Ogden, Utah. 117 p.

Guthery, F. S., T. E. Anderson, and V. W. Lehmann. 1979. Range rehabilitation enhances cotton rate in South Texas. *Journal of Range Management* 32:354-356.

Gysel, L. W., and L. J. Lyon. 1980. Habitat analysis and evaluation. In Wildlife technical manual, ed. S. D. Schemnitz, 305-327. Washington, DC: The Wildlife Society.

Hahnkamp, C. and D. Pence. 1984. East pioneer noxious weed control program. In proceedings of the Knapweed Symposium. Bulletin 1315. Bozeman: Montana State University, Plant and Soil Science Department and Cooperative Extension Service.

Halifax, J. C., and C. J. Scifres. 1972. Influence of dicamba on development of range grass seedlings. *Weed Science* 20:414-416.

Hall, R. J. 1980. Effects of environmental contaminants in reptiles: A review. Special Science Report no. 228. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service.

Halter, M. T. 1980. 2,4-D in the aquatic environment. In Literature reviews of four selected herbicides: 2,4-D, Dichlobenil, Diquat, and Endothall. Seattle, WA: Municipality of Metropolitan Seattle.

Hansen, W. H., M. L. Quaife, R. T. Haberman, and O. G. Fitzhugh. 1971. Chronic toxicity of 2,4-D in rats and dogs. *Toxicology and Applied Pharmacology* 20:111-129.

Hardell, L. and A. Sandstrom. 1979. Case-control study: Soft tissue sarcomas and exposure to phenoxyacetic acids or chlorophenols. *British Journal of Cancer* 39:7711-7717.

Hardell, L., M. Eriksson, and P. Lenner. 1981. Malignant lymphoma and exposure to chemicals, expecially organic solvents, chlorophenols, and phenoxy acids: A case-control study. *British Journal of Cancer* 43:1169-1176.

Harlow, W. M., and E. S. Harrar. 1953. *Textbook of dendrology*. New York: McGraw-Hill Book Co.

Harniss, R. O., and R. B. Murray. 1973. 30 years of vegetal change following burning of sagebrush-grass range. *Journal of Range Management* 26:322-325.

Harper, J. L. 1977. *Population biology of plants*. New York: Academic Press.

REFERENCES

Hastings, J. R., and Turner, R. M. 1965. *The changing mile.* Tucson, AZ: University of Arizona Press.

Hawkins, R. H. 1987. Applied hydrology in the pinyon-juniper type. In Proceedings of pinyon-juniper conference, comp. R. L. Everett. General Technical Report INT-215, 493-504. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Station.

Hayes, A. W. 1982. *Principles and methods of toxicology.* New York: Raven Press.

Hayes, W. J. 1982. *Pesticides studied in man.* Baltimore: Williams and Wilkins.

Hazelton Laboratories. 1986. Pathology summary on carcinogenicity in mice with 2,4-dichlorophenoxyacetic acid, unscheduled deaths, and terminal sacrifice. Unpublished report. Project #2184-101. Vienna, VA.

Heath, R. C. 1984. Ground-water regions of the United States. U.S. Geological Survey Water Supply paper 2242. Washington, DC: U.S. Government Printing Office.

Hendricks, B. A., and J. M. Johnson. *Effects of fire on steep mountain slopes in central Arizona.*

Herbel, C. H. 1984a. Manipulative range improvements: summary and recommendations. In Developing strategies in rangeland management, 1167-1178. National Research Council/ National Academy of Sciences. Boulder, CO: Westview Press.

Herbel, C. H. 1984b. Successional patterns and productivity potentials of range vegetation in the warm, arid portions of the southwestern United States. In Developing strategies in rangeland management, 1333-1365. National Research Council/National Academy of Sciences. Boulder, CO: Westview Press.

Herbel, C. H. 1985. Vegetation changes on arid rangelands of the southwest. *Journal of Range Management* 7:19-21.

Herbel, C. H., G. H. Abernathy, C. C. Yarbrough, and D. K. Gardner. 1973. Rootplowing and seeding arid rangelands in the southwest. *Journal of Range Mangement* 26:193-197.

Hibbert, A. R., E. A. Davis, and D. G. Scholl. 1974. Chaparral conversion potential. Part I: Water yield response and effects on other resources. Research Paper RM-126. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Station.

Hickerson, J. 1986. Artemisia spinescens. In Fire effects information system (data base), comp. William C. Fischer. Missoula, MT: United States Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory.

Hironaka, M., M. A. Fosberg, and A. H. Winward. 1983. Sagebrush-grass habitat types of southern Idaho. Bulletin No. 35, Moscow, ID: University of Idaho, Forest, Wildlife, and Range Experiment Station.

Hoar, S. K., A. Blair, F. F. Holmes, C. D. Boysen, R. J. Robel, R. Hoover, and J. F. Fraumeni, Jr. 1986. Agricultural herbicide use and risk of lymphoma and soft-tissue sarcoma. *Journal of the American Medical Association* 256 (9): 1141-1147.

Hobbs, N. T., and R. A. Spowart. 1984. Effects of prescribed fire on nutrition of mountain sheep and mule deer during winter and spring. *Journal of Wildlife Management* 48:551-560.

Hoerger, F., and E. E. Kenaga. 1972. Pesticide residues on plants: Correlation of representative data as a basis for estimation of their magnitude in the environment. In *Environmental quality and safety.* Vol. 1, Global aspects of toxicology and technology as applied to the environment, ed. F. Coulston. New York: Academic Press.

Hoffman, D. J., and P. H. Albers. 1984. Evaluation of potential embryotoxicity and teratogenicity of 42 herbicides, insecticides, and petroleum contaminants to mallard eggs. *Archives of Environmental Contamination and Toxicology.* 13:15-27.

Holechek, J. L., R. D. Pieper, and C. H. Herbel. 1989. *Range management principles and practices. Englewood Cliffs, NJ: Prentice Hall.*

Hollfield, J. L. 1987a. *Ceratoides lanata.* In Fire effects information system (data base), comp. William C. Fischer. Missoula, MT: United States Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory.

Hollfield, J. L. 1987b. *Cowania mexicana var. stansburiana.*

Hollfield, J. L. 1987c. *Grayia spinosa.*

Hollfield, J. L. 1987d. *Hilaria jamesii.*

Hollfield, J. L. 1987e. *Opuntia polycantha.*

Houston, W. R. 1977. Species susceptibility to atrazine herbicide on shortgrass range. *Journal of Range Management* 30:50-52.

Howard, R. P., and M. L. Wolfe. 1976. Range improvement practices and ferroginous hawks. *Journal of Range Management* 29:33-37.

Howard, V. W., Jr., K. M. Cheap, R. H. Hier, T. G. Thompson, and J. A. Dimas. 1987. Effects of cabling pinyon-juniper on mule deer and lagomorph use. In Proceedings pinyon-juniper conference, comp. R. L. Everett, 552-557. General Technical Report INT-215. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Station.

Howard, W. E., R. L. Fenner, and H. E. Childs. 1959. Wildlife survival in brush burns. *Journal of Range Management* 12:230-234.

Hubbard, W. A. 1975. Increased range forage production by reseeding and the chemical control of knapweed. *Journal of Range Management* 28:406-407.

Hudson, R. H., R. K. Tucker, and M. A. Haegele. 1984. *Handbook of toxicity of pesticides to wildlife.* 2d ed. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service.

Humphrey, R. R. 1962. *Range ecology.* NY: Ronald Press.

Humphrey, R. R., and L. A. Mehrhoff. 1958. Vegetation changes on Arizona grassland ranges. *Ecology* 39:720-726.

Hunt, C. B. 1973. *Natural regions of the United States and Canada.* San Francisco: W. H. Freeman and Co.

Hunter, R., A. Wallace, and E. M. Rohney. 1978. Persistent atrazine toxicity in Mohave Desert shrub communities. *Journal of Range Management* 31:199-203.

Hurd, R. M. 1955. Effect of 2,4-D on some herbaceous range plants. *Journal of Range Management* 8:126-128.

Hutchinson, V. H., W. G. Whitford, and M. Kohl. 1968. Relation of body size to gas exchange in anurans. *Physiological Zoology* 41:65-85.

Hutten, N. C., and G. F. Gifford. 1988. Some hydrologic impacts of plowing rangeland soils. *Water Resources Bulletin* 24:175-181.

Hyder, D. N. 1971. Species susceptibilities to 2,4-D on mixed-grass prairie. *Weed Science* 19:526-528.

Hyder, D. N., and F. A. Sneva. 1962. Selective control of big sagebrush associated with bitterbrush. *Journal of Range Management* 15:211-215.

REFERENCES

ICPEMC Committee 1. 1983. Final report: Screening strategy for chemicals that are potential germ-cell mutagens in mammals. *Mutation Research* 114:117-177.

Innes, J. R. J., B. M. Ulland, M. G. Valerio, L. Petrucelli, L. Fishbein, E. R. Hart, A. J. Pallota, R. R. Bates, H. L. Falk, J. J. Gart, M. Klein, I. Mitchell, and J. Peters. 1969. Bioassays of pesticides and industrial chemicals for tumorigenicity in mice: A preliminary note. *Journal of the National Cancer Institute* 42:1101-1114.

International Technical Information Institute. 1976. Toxic and hazardous industrial chemicals safety manual. Tokyo, Japan.

Irvine, A. M., J. C. Forbes, and S. R. Draper. 1977. Effect of 2,4-D on the water-soluble carbohydrate content of ragwort (Senecio jacobaea L.) leaves. *Weed Research* 17:169-172.

Jackson, J. B. 1966. Toxicologic studies on a new herbicide in sheep and cattle. *American Journal of Veterinary Research* 27 (118): 821-824.

Jacoby, P. W., D. N. Ueckert, and F. S. Hartman. 1982. Control of creosotebush (Larrea tridentata) with pelleted tebuthiuron. *Weed Science* 30:307-310.

Jager, D. J. 1972. The influence of cultural practices and seeded species on overland flow and sediment production from the big sagebrush cover type in East Gate Basin. Ph.D. diss., University of Nevada, Reno.

James, S. 1984. Lignotubers and burls—Their structure, function and ecological significance in Mediterranean ecosystems. *Botanical Review* 50 (3): 225-266.

Jameson, D. A. 1962. Effects of fire on galleta-black grama range invaded by juniper. *Ecology* 43:760-763.

Jenson, E. A. 1984. Data requirements for economic evaluation of a knapweed containment program. In Proceedings of the Knapweed Symposium. Bulletin 1315. Bozeman: Montana State University, Plant and Soil Science Department and Cooperative Extension Service.

John-Greene, J. A., J. H. Ouellette, T. K. Jeffries, K. A. Johnson, and K. S. Rao. 1985. Teratological evaluation of picloram potassium salts in rabbits. *Food Chemistry Toxicology* 23 (8): 753-756.

Johnson, C. R. 1976. Herbicide toxicities in some Australian anurans and the effect of subacute dosages on temperature tolerance. *Zoological Journal of the Linnean Society* 59:79-83.

Johnson, J. R., and G. F. Payne. 1968. Sagebrush reinvasion as affected by some environmental influences. *Journal of Range Management* 21:209-213.

Johnson, K. L. 1987. Sagebrush types as ecological indicators to integrated pest management (IPM) in the sagebrush ecosystem of western North America. In Integrated pest management on rangeland. State of the art in the sagebrush ecosystem, ARS-50, ed. J. A. Onsager, 1-10. U.S. Department of Agriculture, Agriculture Research Service. Springfield, VA: National Technical Information Service.

Johnson, R. R. and L. T. Haight. 1985. Avian Use of Xeroriparian Ecosystems in the North American Warm Deserts. *In Riparian Ecosystems and Their Management: Reconciling Conflicting Uses*. pp 156-160. Tucson, AZ.

Johnsen, T. N., Jr. 1987. Using herbicides for pinyon-juniper control in the Southwest. In Proceedings—Pinyon-juniper conference. General Technical Report INT-215. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Station.

Johnsen, T. N., Jr., and W. L. Warskow. 1980. Effects of fall burning of chaparral woodland on soil residues of picloram. *Weed Science* 28:282-284.

Johnson, W. W., and M. T. Finley. 1980. Handbook of acute toxicity of chemicals to fish and aquatic invertebrates. Resource Publication no. 137. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service.

Jones, J. R., and N. V. DeByle. 1985. Fire. In Aspen: Ecology and management in the western United States, eds. Norbert V. DeByle and Robert P. Winokur. General Technical Report RM-119, pp. 77-81. Fort Collins, CO: United States Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Jones, R. D. 1983. Rotomowing antelope bitterbrush—Preliminary report. In Proceedings, research and management of bitterbrush and cliffrose in western North America, comp. A. R. Tiedemann and K. L. Johnson, 158-162. General Technical Report INT-152. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Station.

Jones, V.E., and R.D. Petit. 1984. Low Rates of Tebuthiuron for Control of Sand Shinnery Oak. *Journal of Range Management* 37:488-490.

Jordan, G. L. 1981. Range seeding and brush management on Arizona rangelands. T81121. Tucson, AZ: University of Arizona, Agricultural Experiment Station.

Jorgensen, J. R., and C. S. Hodges. 1971. Effects of prescribed burning on microbial characteristics of soil. Prescribed burning proceedings. U.S. Department of Agriculture, Forest Service, Southeast Station.

Jurgensen, M. F., M. J. Larsen, and A. E. Harvey. 1979. Forest soil biology-timber harvesting relationships. General Technical Report INT-69. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station.

Kearney, P. C., J. E. Oliver, C. S. Helling, A. R. Isensee, and A. Kontson. 1977. Distribution, movement, persistence, and metabolism of N-nitrosoatrazine in soils and a model aquatic ecosystem. *Journal of Agriculture and Food Chemistry* 25 (5): 1177-1181.

Keaschall, J. L., J. M. Laughlin, and R. E. Gold. 1986. Effect of laundering procedures and functional finishes on removal of insecticides selected from three chemical classes. In Performance of protective clothing. ASTM STP 900, ed. R. L. Baker and G. C. Coleta, 162-176. Philadelphia: American Society for Testing and Materials.

Keay, J. A., and J. M. Peek. 1980. Relationships between fires and winter habitat of deer in Idaho. *Journal of Wildlife Management.*

Keeley, J. E. 1987. Role of fire in seed germination of woody taxa in California chaparral. *Ecology* 68 (2): 434-443.

Keeley, J. E., and P. H. Zedler. 1978. Reproduction of chaparral shrubs after fire: a comparison of sprouting and seeding strategies. *American Midland Naturalist* 99:142-161.

Kelsey, R. G. 1984. Living with spotted knapweed minimizing economic impact research possibilities. In Proceedings of the Knapweed Symposium. Bulletin 1315. Bozeman: Montana State University, Plant and Soil Science Department and Cooperative Extension Service.

Kenaga, E. E. 1969. TORDON herbicides—evaluation of safety to fish and birds. *Down to Earth* 25 (1): 5-9.

Kenaga, E. E. 1979. Acute and chronic toxicity of 75 pesticides to various animal species. *Down to Earth* 35 (2): 25-31.

REFERENCES

Kendeigh, S. C. 1969. Tolerance of cold and Bergmann's rule. *The Auk* 86:13-25.

Kendeigh, S. C. 1970. Energy requirements for existence in relation to size of bird. *The Condor* 72:60-65.

Kirsch, L. M., and A. D. Kruse. 1972. Prairie fires and wildlife. Tall timbers fire ecology conference. 12:289-305.

Klebenow, D. A. 1985. Big game response to fire in sagebrush-grass rangelands. *In Rangeland fire effects*, 53-57.

Klebenow, D. A., R. Beall, A. Bruner, R. Mason, B. Roundy, W. Stager, and K. Ward. 1976. Controlled fire as a management tool in the pinyon-juniper woodland, Nevada. Annual Progress Report. Reno, NV: University of Nevada.

Klebenow, D. A., and R. C. Beall. 1977. Fire impacts on birds and mammals on Great Basin rangelands. *In Rangeland management fire symposium*, 59-62. Casper, WY.

Klomp, G. J., and A. C. Hull, Jr. 1968a. Effects of 2,4-D on emergence and seedling growth of range grasses. *Journal of Range Management* 21:67-70.

Klomp, G. J., and A. C. Hull, Jr. 1968b. Herbicidal residues on crested wheatgrass. *Weeds* 16:315-317.

Klots, E. B. 1966. The new field book of freshwater life. *Putnam Nature Field Book*. New York: G.P. Putnam's Sons.

Knopf, F. L., R. R. Johnson, T. Rich, F. B. Samson, and R. C. Szaro. 1988. Conservation of riparian ecosystems in the United States. Wilson Bulletin, 100 (2): 272-284.

Knutson, Lloyd. 1990. Biological Control of Weeds Laboratory-Europe Shipment Records, Section IV and V. 1980-1989. USDA-ARS, Rome, Italy.

Kociba, R. J. and R. W. Mullison. 1985. Toxicological interactions with agricultural chemicals. *Farm Supplier*, August 1985.

Koeman, J. H., T. Horsmans, and H. L. Maas. 1969. Accumulation of diuron in fish. *Mededelingen Rijksfakulteit Landbouw Wetenschappen Gent* 34 (3): 428-433.

Kolmodin-Hedman, B., S. Hoglund, and M. Akerblom. 1983. Studies on phenoxy acid herbicides. I. Field study: occupational exposure to phenoxy acid herbicides (MCPA, Dichlorprop, Mecoprop and 2,4-D) in agriculture. *Archives of Toxicology* 54:257-265.

Kopischke, E. D. 1972. The effect of 2,4-D and diesel fuel on egg hatchability. *Journal of Wildlife Management* 36:1353-1356.

Korthuis, S. L. 1988a. Fire effects information system (data base), comp. William C. Fischer. Missoula, MT: United States Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory.

Korthuis, S. L. 1988b. Larrea tridentata. In Fire effects information system (data base), comp. William C. Fischer. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Science Laboratory.

Krausman, P. R., K. R. Rautenstrauch, and B. D. Leopold. 1985. Xeroriparian Systems Used by Desert Mule Deer in Texas and Arizona. *In Riparian Ecosystems and Their Management: Reconciling Conflicting Uses*. pp 144-149. Tucson, AZ.

Kufeld, R. C. 1968. Range type-conversion programs in Colorado and their impact on deer, elk and sage grouse. Western Association State Game and Fish Commissioners proceedings, 48:173-157.

Kufeld, R. C. 1977. Improving Gambel oak ranges for elk and mule deer by spraying with 2,4,5-TP. *Journal of Range Management* 30:53-57.

Kundaeli, J. N., and H. G. Reynolds. 1972. Desert cottontail use of natural and modified pinyon-juniper woodland. *Journal of Range Management* 25:116-118.

Laboratory-Europe. Biological Control of Weeds, Laboratory-Europe Shipment Records 1980-1989.

Lacey, C. A. and P. K. Fay. 1984. Montana's spotted knapweed awareness program. In Proceedings of the Knapweed Symposium. Bulletin 1315. Bozeman: Montana State University, Plant and Soil Science Department and Cooperative Extension Service.

Lagier, R. F. et al. 1974. Adjuvants decrease insecticide hazard to honey bees. College of Agriculture Research Center bulletin no. 801. Pullman, WA: Washington State University.

Lancaster, D. L., J. A. Young, and R. A. Evans. 1987. Weed and brush control tactics in the sagebrush ecosystem. In Integrated pest management on rangeland. State of the art in the sagebrush ecosystem, ed. J. A. Onsager, 11-14. U.S. Department of Agriculture, Agriculture Research Service. Springfield, VA: National Technical Information Service.

Lanner, R. M. 1977. The eradication of pinyon-juniper woodland: has the program a legitimate purpose? *Western Wildlands Spring Issue*. pp 12-17.

Lasiewski, R. C., and W. A. Calder, Jr. 1971. A preliminary allometric analysis of respiratory variables in resting birds. *Respiration Physiology* 11:152-166.

Lasiewski, R. C., and W. R. Dawson. 1967. A reexamination of the relation between standard metabolic rate and body weight in birds. *The Condor* 69:13-23.

Laughlin, J. M., C. B. Easley, R. E. Gold, and R. M. Hill. 1986. Fabric parameters and pesticide characteristics that impact on dermal exposure of applicators. In Performance of protective clothing ASTM STP 900, ed. R. L. Baker and G. C. Coleta, 13-150. Philadelphia: American Society for Testing and Materials.

Lavy, T. L., and J. D. Mattice. 1986. Progress in pesticide exposure and future concerns. *Toxicology Letters* 33:61-71.

Lavy, T. L., J. D. Mattice, and L. A. Norris. 1984. Exposure of forestry applicators using formulations containing 2,4-D, dichlorprop, or picloram in non-aerial applications. Prepared for the U.S. Department of Agriculture, Forest Service. Corvallis, OR.

Lavy, T. L., L. A. Norris, J. D. Mattice, and P. B. Marx. 1987. Exposure of forestry ground workers to 2,4-D, picloram and dichlorprop. *Environmental Toxicology and Chemistry* 6:209-224.

Lavy, T. L., J. S. Shepar, and J. D. Mattice. 1980. Exposure measurements of applicators spraying (2,4,5-trichlorophenoxy)acetic acid in the forest. *Journal of Agricultural and Food Chemistry* 28:626-630.

Lavy, T. L., J. D. Walstad, R. R. Flynn, and J. D. Mattice. 1982. (2,4-Dichlorophenoxy) acetic acid exposure received by aerial application crews during forest spray operations. *Journal of Agricultural and Food Chemistry* 30:375-381.

Leege, T. A., and W. O. Hickey. 1971. Sprouting of northern Idaho shrubs after prescribed burning. *Journal of Wildlife Management* 35:508-515.

Leininger, Wayne C. 1988. Non-chemical alternatives for managing selected plant species in the western United States. Fort Collins: Colorado State University.

Leonard, S. G.; R. L. Miles; H. A. Summerfield. 1987. Soils of the pinyon-juniper woodlands, pp. 227-230. IN Proc. Pinyon-Juniper Conference. USDA Forest Service. Gen. Tech. Rep. INT-215. Intermountair Research Station. Ogden, Utah.

Leonas, K. K., and J. O. DeJonge. 1986. Effect of functional finish barriers on pesticide penetration. In Performance of protective clothing. ASTM STP 900, ed. R. L. Baker and G. C. Coleta, 177-186. Philadelphia: American Society for Testing and Materials.

Lewiston Morning Tribune. 1980. Weeds cost more than insects, disease, (article quoting Gary Lee, University of Idaho, Plant and Soil Science Dept.), November 11, 1980. Lewiston, Idaho.

Libich, S., J. C. To, R. Frank, and G. J. Sirons. 1984. Occupational exposure of herbicide applicators to herbicides used along electric power transmission line right-of-way. *Journal of the American Industrial Hygiene Association* 45 (1): 56-62.

Lillywhite, H. B. 1977. Animal responses to fire and fuel management in chaparral. In Symposium on the environmental consequences of fire and fuel management in Mediterranean ecosystems, 368-373. General Technical Report WO-3. U.S. Department of Agriculture, Forest Service.

Lindon, E., B. E. Bengtsson, O. Svanberg, and G. Sunstrom. 1979. The acute toxicity of 78 chemicals and pesticide formulations against two brackish water organisms, the Bleak (Alburnus alburnus) and the Harpacticoid (Nitocra spinipes). *Chemosphere* 8 (11-12): 843-851.

Loomis, T. A. 1978. *Essentials of toxicology*. Philadelphia: Lea and Febiger.

Lorenz, R. J. 1986. Introduction and early use of crested wheatgrass in the northern Great Plains. In Crested wheatgrass: its values, problems and myths. Proceedings of a symposium, ed. K. L. Johnson, 9-20. Logan, UT: Utah State University.

Lotan J. E., and L. J. Lyon. 1981. Effects of fire on flora: A state-of-the-knowledge review. General Technical Report WO-16. U.S. Department of Agriculture, Forest Service.

Lowe, P. O., P. F. Ffolliott, J. H. Dieterici, and D. R. Patton. 1978. Determining potential wildlife benefits from wildfire in Arizona ponderosa pine forests. General Technical Report RM-52. U.S. Department of Agriculture, Forest Service.

Lull, H. W. 1959. Soil compaction on forest and rangelands. Miscellaneous Publication No. 768. Washington, DC: U.S. Department of Agriculture, Forest Service.

Lusby, G. C. 1979. Effects of converting sagebrush cover to grass on the hydrology of small watersheds at Boco Mountain, Colorado. Water Supply paper 1532-J. U.S. Geological Survey.

Lynge, E. 1985. A follow-up study of cancer incidence among workers in manufacture of phenoxy herbicides in Denmark. *British Journal of Cancer* 52:259-270.

Lynn, G. E. 1965. A review of toxicological information on TORDON herbicides. *Down to Earth Spring* 1965:6-8.

Lyon, J. L., and J. E. Lotan. 1978. Effects of fire on fauna: A state-of-knowledge-review. General Technical Report WO-6. U.S. Department of Agriculture, Forest Service.

Lyon, L. J., and W. F. Mueggler. 1968. Herbicide treatment of north Idaho grouse evaluated six years later. *Journal of Wildlife Management* 32:538-541.

MacMahon, B. 1986. A review of the Hoar et al. study on agricultural herbicide use and risk of lymphoma and soft tissue sarcoma. Report prepared for the Environmental Protection Agency. Cambridge, MA: Harvard School of Public Health.

MacMahon, J. A. 1985. *Deserts: The Audubon Society nature guides*. New York: Alfred A. Knopf.

Mansdorf, S. Z. 1986. Risk assessment of chemical exposure hazards in the use of protective clothing—an overview. In Performance of protective clothing. ASTM STP 900, ed. R. L. Baker and G. C. Coleta, 207-213. Philadelphia: American Society for Testing Materials.

Mantel, N., and M. A. Schneiderman. 1975. Estimating "safe" levels: a hazardous undertaking. *Cancer Research* 35:1379-1386.

Marquiss, R. W. 1972. Soil moisture, forage and beef production benefits from Gambel oak control in southwestern Colorado. *Journal of Range Management* 25:146-150.

Marquiss, R. W. 1973. Gambel oak control studies in Southwestern Colorado. *Journal of Range Management* 26:57-71.

Martin, S. C. 1975. Ecology and management of southwestern semidesert grass-shrub ranges: The status of our knowledge. Research Paper RM-156. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Station.

Martin, S. C. 1983. Responses of semidesert grasses and shrubs to fall burning. *Journal of Range Management* 36:604-610.

Martin, S. C., and H. L. Morton. 1980. Responses of false mesquite, native grasses and forbs, and Lehmann lovegrass after spraying with picloram. *Journal of Range Management* 33:104-106.

Martin, S. C., and H. G. Reynolds. 1973. The Santa Rita experimental range: Your facility for research on semi-desert ecosystems. *Arizona Academy of Science* 8:56-67.

Martin, S. C., S. J. Shellhorn, and H. M. Hull. 1970. Emergence of fourwing saltbush after spraying shrubs with picloram. *Weed Science* 18:389-392.

Martin, S. C., and R. M. Turner. 1977. Vegetation changes in the Sonoran Desert region, Arizona and Sonora. *Journal of the Arizona Academy of Sciences* 12:59-69.

Marzulli, F. N., and H. I. Maibach. 1983. *Dermatotoxicology*. 2d ed. New York: Hemisphere Publishing.

Maser, C., and J. W. Thomas. 1983. Wildlife habitats in managed rangelands—The Great Basin of southeastern Oregon. Introduction. U.S. Department of Agriculture, Forest Service, General Technical Report PNW-160 - United States, Pacific Northwest Forest and Range Experiment Station.

Matsunaga, E. 1982. Perspectives in mutation epidemiology: Incidence and prevalence of genetic diseases (excluding chromosomal aberrations) in human populations. *Mutation Research* 99:95-128.

Maxwell, R. 1982. Meaning of label signal words. Pesticide Report 43:4-5. Pullman, WA: Washington State University, Cooperative Extension Service.

Mayer, F. L., Jr., and M. R. Ellersieck. 1986. Manual of acute toxicity: interpretation and data base for 410 chemicals and 66 species of freshwater animals. Resource Publication no. 160. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service.

Mayes, M. A., and D. C. Dill. 1984. The acute toxicity of picloram, picloram potassium salt, and picloram triisopropanolamine salt to aquatic organisms. *Environmental Toxicology and Chemistry* 3:263-269.

Mayes, M. A., D. C. Dill, K. M. Bodner, and C. G. Mendoza. 1984. Triclopyr triethylamine salt toxicity to life stages of the fathead minnow (Pimephales promelas Rafinesque). *Bulletin of Environmental Contamination and Toxicology* 33:339-347.

REFERENCES

Mayes, M. A., D. L. Hopkins, and D. C. Dill. 1987. Toxicity of picloram (4-amino-3,5,6,-trichloropicolinic acid) to life stages of the rainbow trout. *Bulletin of Environmental Contamination and Toxicology* 38:653-660.

McAdoo, J. K., R. A. Evans, and W. S. Lougland. 1986. Nongame bird responses to type conversion of sagebrush communities. In Crested wheatgrass: Its values, problems and myths. Proceedings of a symposium, ed. K. L. Johnson, 55-163. Logan, UT: Utah State University.

McAdoo, J. K., and D. A. Klebenow. 1978. Native faunal relationships in sagebrush ecosystems. In The sagebrush ecosystem: A symposium, p. 50-61. Logan, UT: Utah State University, College of Natural Resources.

McCarty, M. K. 1979. Yield and quality of two cool-season grasses as affected by selected herbicides. *Weed Science* 27:415-421.

McCarty, M. K., and C. J. Scifres. 1972. Herbicidal control of western ragweed in Nebraska pastures. *Journal of Range Management* 25:290-292.

McCollister, D. C., and M. L. Leng. 1969. Toxicology of picloram and safety evaluation of TORDON herbicides. *Down to Earth* 25 (2): 5-10.

McCormick, D. P. 1975. Effect of mesquite control on small game populations. Master's thesis, University of Arizona, Tucson.

McCracken, J. G. 1981. Coyote foods in southwestern Colorado. *The Southwestern Naturalist* 26 (3):317-318.

McCulloch, C. Y. 1969. Some effects of wildfire on deer habitat in pinyon-juniper woodland. *Journal of Wildlife Management* 33:778-784.

McDaniel, K. C. 1984. Snakeweed control with herbicides. Bulletin 706. Las Cruces, NM: New Mexico State University, Agricultural Research Station.

McDaniel, K. C., R. D. Pieper, and G. B. Donart. 1982. Grass response following thinning of broom snakeweed. *Journal of Range Management* 35:219-222.

McEwen, L. C., and L. R. DeWeese. 1987. Wildlife and pest control in the sagebrush ecosystem: Basic ecology and management considerations. In Integrated pest management on rangeland, state of the art in the sagebrush ecosystem, ed. J. A. Onsager, 76-85. U.S. Department of Agriculture, Agricultural Research Service. Springfield, VA: National Technical Information Service.

McGee, J. M. 1982. Small mammal populations in an unburned and early fire successional sagebrush community. *Journal of Range Management* 35:177-180.

McKusick, V. A. 1983. Mendelian inheritance in man. 6th ed. Baltimore, MD: Johns Hopkins University Press.

McMurray, N. 1986a. *Cercocarpus ledifolius.* In Fire effects information system (data base), comp. William C. Fischer. Missoula, MT: United States Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory.

McMurray, N. 1986b. *Pinus edulis.* In Fire effects information system (data base), comp. William C. Fischer. Missoula MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Science Laboratory.

McMurray, N. 1986c. *Pinus monophylla.* In Fire effects information system (data base), comp. William C. Fischer. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Science Laboratory.

McMurray, N. 1986d. *Symphoricarpos longiflorus.*

McMurray, N. 1986e. *Symphoricarpos oreophilus.*

McMurray, N. 1987a. *Artemisia cana ssp. cana.* In Fire effects information system (data base), comp. William C. Fischer. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Science Laboratory.

McMurray, N. 1987b. *Artemisia cana* ssp. *viscidula.* In Fire effects information system (data base), comp. William C. Fischer. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Science Laboratory.

McMurray, N. 1987c. *Artemisia nova.*

McMurray, N. 1987d. *Cercocarpus montanus.*

McMurray, N. 1987e. *Festuca scabrella.*

McMurray, N. 1987f. *Leymus cinereus.*

McMurray, N. 1987g. *Prunus virginiana.*

Mecler, F. J. and R. P. Beliles. 1979. Teratology study in rats: Diesel fuel final report. American Petroleum Institute Medical Research Publication no. 27-32174. Washington, DC: American Petroleum Institute.

Meeuwig, R. O. 1971. Soil stability on high-elevation rangeland in the intermountain areas. Research Paper INT-94. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station.

Mehringer, P.; and P. E. Wigand. 1987. Western juniper in the Holocene, pp. 109-119. In Proc. Pinyon-Juniper Conference. USDA Forest Service. Gen. Tech. Rep. INT-215. Intermountain Research Station. Ogden, Utah.

Melzian, B. D. 1983. Acute toxicity, histopathy, and bioconcentration retention studies with no. 2 fuel oil and the blue crab, Callinectes sapidus Rathbun. Dissertation Abstracts International B: The Sciences and Engineering 43 (11).

Messersmith, C. G. and R. G. Lym. 1983. Distribution and economic impacts of leafy spurge in North Dakota. North Dakota Farm Research Bulletin, Vol. 40, No. 5, March-April, 1983.

Meyer, R. E., and R. W. Bovey. 1979. Control of honey mesquite (Prosopis juliflora var. glanduolosa) and Macartney rose (Rosa bracteata) with soil-applied herbicides. *Weed Science* 27:280-284.

Meyerhoff, Roger. personal communication. 1990.

Miles, J. 1979. Vegetation dynamics. *Halsted Press Book.* John Wiley and Sons, New York. 80 p.

Miller, C. O. M. 1980. A mathematical model of aerial deposition of pesticides from aircraft. *Environmental Science and Technology* 14:824-831.

Miller, M. 1977. Response of blue huckleberry to prescribed fires in a western Montana larch-fir forest. Research Paper INT-188. Ogden, UT: United States Department of Agriculture, Forest Service. Intermountain Research Station.

Miller, M. 1987. Field observation. Fire ecology. U.S. Department of Interior, Bureau of Land Management. Boise, ID: Boise Interagency Fire Center.

Miller, M. 1987. Personal observation.

Miller, M. (ibid). 1988. Personal observation.

Miller, M. 1989. Personal communication, 3 January 1989, regarding use of prescribed fire in BLM's Vegetation Treatment Program. Boise, ID: BLM Branch of Fire Science.

REFERENCES

Miller, R. R. 1961. Man and the Changing Fish Fauna of the American Southwest. Michigan Academy of Science, Arts, and Letters. Vol. XLVI.

Mitsuda, H., K. Murakami, and F. Kawai. 1963. Effect of chlorophenol analogues on the oxidative phosphorylation in rat liver mitochondria. *Agricultural and Biological Chemistry* 27:366.

Moffett, J. O., H. L. Morton, and R. L. MacDonald. 1972. Toxicity of some herbicidal sprays to honey bees. *Journal of Economic Entomology* 65 (1): 32-36.

Molini, W. A., State of Nevada, Dept of Wildlife. 1990. personal communication.

Monsanto Company. n.d. Toxicity information provided by Tim Long of Monsanto Agricultural Products Division to Paul Mistretta, U.S. Forest Service, 1987.

Monsanto Agricultural Products Company. 1982. The health and environmental safety aspects of Roundup herbicide: An overview. Roundup herbicide bulletin no. 3. St. Louis, MO: Monsanto Company.

Monsanto Company. 1983. Rodeo herbicide: Toxicological and environmental properties. Bulletin no. 1. St. Louis, MO: Agricultural Products Company, Environmental Practices.

Monsanto Company. 1985. Material safety data for Roundup herbicide. St. Louis, MO.

Moore, J. A. 1964. *Physiology of the amphibia*. New York: Academic Press.

Morgan, P., and L. F. Neuenschwander. 1988. Shrub response to high and low severity burns following clear-cutting in northern Idaho. *Western Journal of Applied Forestry* 3 (1): 5-9.

Morris, M. S. and D. Bedunah. 1984. Some observation on the abundance of spotted knapweed in western Montana. In Proceedings of the Knapweed Symposium. Bulletin 1315. Bozeman: Montana State University, Plant and Soil Science Department and Cooperative Extension Service. Nielsen, Darvin B. 1978. The economic impact of poisonous plants on the range livestock industry in the 17 western states. *Journal of Range Management* 31 (5): 325-328.

Morrow, L. A., and M. K. McCarty. 1976. Selectivity and soil persistence of certain herbicides used on perennial forage grasses. *Journal of Environmental Quality* 5:462-465.

Mueggler, W. F. 1983. Variation in production and seasonal development of mountain grasslands in western Montana. Research Paper INT-316. Ogden, UT: United States Department of Agriculture, Forest Service, Intermountain Research Station.

Mueggler, W. F., and W. L. Stewart. 1980. Grassland and shrubland habitat types of western Montana. General Technical Report INT-66. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station.

Mullison, W. R. 1985. A toxicological and environmental review of picloram. In Proceedings of the 38th Annual Meeting of the Western Society of Weed Science, March 1985. Phoenix, AZ.

Mullison, W. R. 1986. An interim report summarizing 2,4-D toxicological research by the industry task force on 2,4-D research data and a brief review of 2,4-D environmental effects. Peer-reviewed by the technical and toxicology committees of the Industry Task Force on 2,4-D Research Data.

Murray, R. B. 1983. Response of antelope bitterbrush to burning and spraying in southeastern Idaho. In Proceedings—Research and management of bitterbrush and cliffrose in western North America. Comp. A. R. Tiedmann and K. L. Johnson, 142-152. General Technical Report INT-152. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Station.

Murray, R. B. 1988. Response of three shrub communities in southeastern Idaho to spring-applied tebuthiuron. *Journal of Range Management* 41:16-22.

National Research Council. 1977. Drinking water and health. Vol. I. Washington, DC: National Academy Press.

National Research Council. 1987. Pesticides in food—The Delaney paradox. Washington, DC: National Academy Press.

Nash, R. G., P. C. Kearney, J. C. Maitlen, C. R. Sell, and S. N. Fertig. 1982. Agricultural applicators exposure to 2,4-dichlorophenoxyacetic acid. In Pesticide residues and exposures. American Chemical Society symposium series no. 238, pp. 119-132.

National Institute for Occupational Safety and Health. 1987. Registry of toxic effects of chemical substances. Washington, DC: U.S. Department of Health and Human Services.

National Institute for Occupational Safety and Health. 1989. Registry of Toxic Effects of Chemical Substances. Clopyralid file.

National Library of Medicine. 1987. Hazardous substances databank printout on kerosene. Bethesda, MD.

National Library of Medicine. 1987a. Hazardous Substance Data Bank printout on picloram. Bethesda, MD.

National Library of Medicine. 1987b. Hazardous Substance Data Bank printout on kerosene. Bethesda, MD.

National Research Council. 1977. Drinking water and health. Washington, DC: National Academy Press.

National Research Council. 1983. Risk assessment in the Federal Government: managing the process. Washington, DC: National Academy Press.

National Research Council. 1985. Injury in America—A continuing health problem. Washington, DC: National Academy Press.

National Research Council. 1986. Drinking water and health. Vol. 6., ed. R. D. Thomas. Washington, DC: National Academy Press.

National Research Council. 1987. Pharmakinetics in risk assessment: Drinking water and health. Vol. 8. Washington, DC: National Academy Press.

Neary, D. G., P. B. Bush, and J. E. Douglass. 1983. Off-site movement of hexazinone in stormflow and baseflow from forest watersheds. *Weed Science* 31:543-551.

Neff, E. L. and J. R. Wight. 1977. Overwinter soil water recharge and herbage production as influenced by contour processing on eastern Montana rangelands. *Journal of Range Management* 30:193-195.

Newell, K. W., A. D. Ross, and R. M. Renner. 1984. Phenoxy and picolinic acid herbicides and small-intestinal adenocarcinoma in sheep. The Lancet December 8, 1984:1301-1304.

Newton, M., A. Allen, D. E. White, B. R. Kelpsas, and F. Roberts. 1982. Deposits and degradation of herbicides in sclerophyll brushfield foliage. Denver, CO: Western Society of Weed Science.

REFERENCES

Newton, M., and F. N. Dost. 1981. Environmental effects of vegetation management practices on DNF forest lands. Prepared for State of Washington, Department of Natural Resources.

Newton, M. and F. N. Dost. 1984. Biological and physical effects of forest vegetation management. Olympia, WA: Washington Department of Natural Resources.

Newton, M., and J. A. Norgren. 1977. Silvicultural chemicals and protection of water quality EPA 910/9-77-036. Seattle, WA: U.S. Environmental Protection Agency, Region 10.

Newton, M., and L. A. Norris. 1981. Potential exposure of humans to 2,4,5-T and TCDD in the Oregon coast ranges. *Fundamental and Applied Toxicology* 1:339-346.

Nichols, J. T., and W. E. McMurphy. 1969. Range recovery and production as influenced by nitrogen and 2,4-D treatments. *Journal of Range Management* 22:116-119.

Nielsen, D. B. 1978. The economic impact of poisonous plants on the range livestock industry in the 17 western states. *Journal of Range Management* 31(5):325-328.

Nigg, H. N., and J. H. Stamper. 1983. Exposure of Florida airboat aquatic weed applicators to 2,4-dichlorophenoxyactic acid (2,4-D). *Chemosphere* 12 (2): 209-215.

Nimir, M. B., and G. F. Payne. 1978. Effects of spring burning on a mountain range. *Journal of Range Management.* 31 (4): 259-263.

Norris, L. A., and D. G. Moore. 1981. Introduced chemicals and water quality. In Interior, west watershed management symposium: 1980 April 8-10, Spokane, WA, ed. D. M. Baumgartner. 203-220. Pullman, WA: Washington State University, Cooperative Extension.

Norum, R. A., and M. Miller. 1984. Measuring fuel moisture content in Alaska: Standard methods and procedures. General Technical Report PNW-171. Portland, OR: United States Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Noste, N. V., and C. L. Bushey. 1987. Fire response of shrubs of dry forest habitat types in Montana and Idaho. General Technical Report INT-239. Ogden, UT: United States Department of Agriculture, Forest Service, Intermountain Research Station.

O'Neal, F. 1987. Personal communication. Du Pont. Wilmington, DE: Agricultural Products Department.

O'Rourke, J. T., and P. R. Ogden. 1969. Vegetative response following pinyon-juniper control in Arizona. *Journal of Range Management* 22:416-418.

Odum, E. P. 1971. Fundamentals of ecology. Philadelphia: W. B. Saunders, Co.

Odum, E. P., C. E. Connell, and L. B. Davenport. 1962. Population energy flow of three primary consumer components of old-field ecosystems. *Ecology* 43 (1):88-96.

Ohmart, R. D., and B. W. Anderson. 1982. North American desert riparian ecosystems. In Reference handbook on the deserts of North America, ed. Gordon L. Bender. Westport, CN: Greenwood Press.

Orians, G. H. 1986. Opening discussion. Cumulative effects: Setting the stage. In Proceeding of the workshop on cumulative environmental effects: A binational perspective. The Canadian Environmental Assessment Research Council and the U.S. National Research Council.

Osweiler, G. D. 1983. Toxicology of triclopyr herbicide to equine. In American Association of Veterinary Laboratory Diagnosticians 20th Annual Proceedings, 193-202.

Palmer, J. S., and R. D. Radeleff. 1969. The toxicity of some organic herbicides to cattle, sheep, and chickens. U.S. Department of Agriculture, production research report no. 106. Washington, DC: U.S. Government Printing Office.

Parker, K. G. 1979. Use of mechanical methods as a management tool. In *The sagebrush ecosystem: A symposium*, 117-120. Logan, UT: Utah State University, College of National Resources.

Parodi, S., S. DeFlora, M. Carvanna, A. Pino, L. Robbiano, C. Bennicelli, and G. Brambilla. 1981. DNA-damaging activity in vivo and bacterial mutagenicity of sixteen hydrazine derivatives as related quantitatively to their carcinogenicity. *Cancer Research* 41:1469-1482.

Parodi, S., M. Taningher, P. Boero, and L. Santi. 1982. Quantitative correlations amongst alkaline DNA fragmentation, DNA covalent bonding, mutagenicity in the Ames test and carcinogenicity, for 21 compounds. *Mutation Research* 93 (1): 1-24.

Parodi, S., M. Taningher, P. Ruso, M. Pala, D. Vecchio, G. Fassina, and L. Santi. 1983a. Quantitative predictivity of the transformation in vitro assay compared with the Ames test. *Journal of Toxicology and Environmental Health* 12 (4-6): 483-510.

Parodi, S., A. Zunino, L. Ottaggio, M. DeFerrari, and L. Santi. 1983b. Quantitative correlation between carcinogenicity and sister chromatid exchange induction in vivo for a group of 11 N-nitroso derivatives. *Journal of Toxicology and Environmental Health* 11 (3): 337-346.

Patric, J. H., and J. D. Helvey. 1986. Some effects of grazing on soil and water in the eastern forest. General Technical Report NE-115. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeast Forest Experiment Station.

Patten, D. T., and G. H. Cave. 1984. Fire temperature and physical characteristics of a controlled burn in the upper Sonoran desert. *Journal of Range Management* 37:277-280.

Patterson, W. A., III. 1986. A "new ecology" - implications for modern forest management. J. For. 84(2): 93.

Patton, D. R. 1975. Abert squirrel cover requirements in southwestern ponderosa pine. Research Paper RM-145. U.S. Department of Agriculture, Forest Service.

Pearce, N. E., A. H. Smith, J. K. Howard, R. A. Sheppard, H. J. Giles, and C. A. Teague. 1986. Non-Hodgkin's lymphoma and exposure to phenoxy herbicides, chlorophenols, fencing work, and meat works employment: A case-control study. *British Journal of Industrial Medicine* 43:75-83.

Pechanec, J. F. and G. Stewart. 1944. Sagebrush burning...good and bad. U.S. Department of Agriculture Farmer's Bulletin No. 1948.

Peek, J. M. 1986. A review of wildlife management. Englewood Cliffs, NJ: Prentice-Hall.

Pellant, M. 1989. Personal communication. Range Conservation. U.S. Department of the Interior, Bureau of Land Management. Boise, ID: Idaho State Office.

Pellant, M. 1989. Personal conversation. Range Conservationist. USDI Bureau of Land Management. Idaho State Office. Boise, Idaho.

Penhallegon, Ross H. 1983. A pilot weed survey program for the state of Washington. Unpublished master's thesis. Washington State University, Pullman.

Perry, D. A., and S. L. Rose. 1980. Productivity of forest lands as affected by site preparation. In Proceedings of the California conferences on forest tree nutrition and soil fertility, 1980 May 19-20. Redding, CA; 1981 January 22-23; South Lake Tahoe, CA.

REFERENCES

Pet-Edwards, J., W. Chankong, H. S. Rosenkranz, and Y. Y. Haines. 1985. Application of the carcinogenicity prediction and battery selection (CPBS) method to the Gene-Tox data base. *Mutation Research* 153:187-200.

Pettit, R. D. 1974. Effects of picloram and tebuthiuron pellets on sand shinnery oak communities. *Journal of Range Management* 32:196-200.

Pieper, R. D. 1971. Blue grama vegetation responds inconsistently to cholla cactus control. *Journal of Range Management* 24:52-54.

Pimentel, D. 1971. Ecological effects of pesticides on non-target species. Washington, DC: Executive Office of the President, Office of Science and Technology.

Pitt, M. D., R. H. Burgy, and H. F. Heady. 1978. Influences of brush conversion and weather patterns from a northern California watershed. *Journal of Range Management* 31:23-27.

Platts, William S. 1984. Determining and evaluating riparian-stream enhancement needs and fish response. In Pacific Northwest stream habitat management workshop. Arcata, CA: Humbolt State University.

Pogodina, O. N., M. P. Svetlova, N. V. Tomilin, G. B. Pliss, and V. V. Khudolel. 1984. Correlation of mutagenic and carcinogenic activities of certain aromatic amines. *Eksperimental'naya Onkologiya* 6 (4): 23-25.

Pond, F. W. 1961. Mechanical control of Arizona chaparral and some results from brush clearing. In Proceedings of the 5th annual Arizona watershed symposium, 39-441. Phoenix, AZ.

Popendorf, W. J. 1985. Advances in the unified field model for reentry hazards. In Dermal exposure related to pesticide use: Discussion of risk assessment, ed. R. C. Honeycutt, G. Zweig, and N. N. Ragsdale. American Chemical Society symposium series no. 273. Washington, DC.

Popendorf, W. J., and J. T. Leffingwell. 1982. Regulating OP pesticide residues for farm worker protection. *Residue Reviews* 82:125-201.

Putnam, A. R., M. D. Willis, L. K. Binning, and P. F. Boldt. 1983. Exposure of pesticide applicators to nitrofen: Influence of formulation, handling systems, and protective garments. *Journal of Agricultural and Food Chemistry*, v. 31:645-650.

Quimby, D. C. 1966. A review of literature relating to the effects and possible effects of sagebrush control on certain game species in Montana. *Western Association of State Game and Fish Commissioners Proceedings* 46:142-149.

Quinton, D. A., R. G. Horejsi, and J. T. Flinders. 1979. Influence of Goosh control on white-tailed deer diets in north-central Texas. *Journal of Range Management* 32:93-97.

Raheel, M. 1987. Laundering variables in removing carbaryl and atrazine residues from contaminated fabrics. *Bulletin of Environmental Contamination and Toxicology* 39:671-679.

Ralston, C. W., and G. E. Hatchell. 1971. "Effects of prescribed burning on physical properties of soil." In Prescribed burning proceedings. U.S. Department of Agriculture, Forest Service, Southeast Station.

Rauzi, F. 1960. Plant cover increases water intake rate on rangeland soils. Crops and Soils 12:30.

Rauzi, F. 1975. Severe mechanical and chemical range renovation in northeastern Wyoming. *Journal of Range Management* 28:319-326.

Rauzi, F., and C. L. Fly. 1968. Water intake on midcontinental rangelands as influenced by soil and plant cover. Technical Bulletin 1390. U.S. Department of Agriculture.

Renwald, J. D. 1977. Effect of fire on lark sparrow nesting densities. *Journal of Range Management* 30:283-285.

Renwald, J. D., H. A. Wright, and J. T. Flinden. 1978. Effect of prescribed fire on bobwhite quail habitat in the rolling plains of Texas. *Journal of Range Management* 31:65-69.

Reuber, M. D. 1979. Carcinogenicity of 2,4-dichlorophenoxyacetic acid. Unpublished manuscript in files of Bureau of Land Management, Oregon State Office.

Reynolds, H. G., and J. W. Bohning. 1956. Effects of burning on a desert grass-shrub range in southern Arizona. *Ecology*. 37:769-777.

Rich, L. R. 1961. Surface runoff and erosion in the lower chaparral zone—Arizona. Paper 66. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Station.

Richardson, C. W., E. Burnett, and R. W. Bovey. 1979. Hydrologic effects of brush control on Texas rangelands. *American Society of Agricultural Engineers Transactions* 22:315-319.

Ritter, D. F. 1978. Process geomorphology. Dubuque, IA: William C. Brown Company.

Robb, T. W., D. G. Ely, C. E. Rieck, R. J. Thomas, B. P. Glenn, and S. Glenn. 1982. Mefluidide treatment of tall fescue: Effect on nutrient utilization. *Journal of Animal Science* 54 (1).

Robbins, C. S., B. Bruun, H. S. Zim, and A. Singer. 1966. A guide to field identification: *Birds of North America*. New York: Golden Press.

Robertson, L. S., and A. E. Erickson. 1978. Soil compaction. Crops and Soils 30:11-14 (Jan); 7-9 (Feb); 8-10 (Mar).

Roby, G. A., and L. R. Green. 1976. Mechanical methods of chaparral modification. Agriculture Handbook 487. U.S. Department of Agriculture.

Roeth, F. W. 1979. Comparison of dicamba, picloram and 2,4-D for musk thistle (Carduus nutaus) control. *Weed Science* 27:651-655.

Rogers, G. F., and M. K. Vint. 1987. Winter precipitation and fire in the Sonoran Desert. *Journal of Arid Environments* 13:47-52.

Rosenberry, J. L., and W. D. Klimstra. 1971. Annual weight cycles in male and female bobwhite quail. *The Auk* 88:116-123.

Roundy, B. A., G. J. Cloff, J. A. Young, and R. A. Evans. 1983. "Treatment of inland saltgrass and greasewood sites to improve forage production." In Managing intermountain rangelands—Improvement of range and wildlife habitats, 54-61. General Technical Report INT-157. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Station.

Roundy, B. A., and J. A. Young. 1985. Salt deserts of the Great Basin. In Proceedings, selected papers presented at the 38th annual meeting of the Society for Range Management, 34-49. Denver, CO.

Russell, L. B., C. S. Aaron, F. deSerres, W. M. Generoso, K. L. Kannan, M. Shelby, J. Springer, and P. Voytek. 1984. Evaluation of existing mutagenicity bioassays for purposes of genetic risk assessment. *Mutation Research* 134:143-157.

Ruyle, G. B., B. A. Roundy, and J. R. Cox. 1988. Effects of burning on germinability of Lehmann lovegrass. *Journal of Range Management* 41 (5): 401-403.

Ryan, K. C. 1982. Evaluating potential tree mortality from prescribed burning. In Symposium—Site preparation and fuels management in steep terrain, comp. David M. Baumgartner, 167-178, 15-17 February. Pullman, WA: Washington State University Cooperative Extension.

REFERENCES

Ryber, R. A. 1970. Effects of dicamba and picloram on northern Idaho shrubs and trees. Research Note INT-114. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Station.

Salish, M. S. A., F. K. Taha, and G. F. Payne. 1973. Water repellency of soils under burned sagebrush. *Journal of Range Management* 26:330-331.

Sampson, A. W. 1944. Plant succession on burned chaparral lands in northern California. Bulletin 685. University of California, College of Agriculture, Agricultural Experiment Station.

Sanders, H. O. 1969. Toxicity of pesticides to the crustacean Gammarus lacustris. Technical paper no. 25. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife.

Sanders, H. O., and O. B. Cope. 1968. The relative toxicities of several pesticides to naiads of three species of stone flies. *Limnology and Oceanography* 13 (1): 112-117.

Santa Marla, C., M. G. Vilas, F. G. Murlana, and A. Relimpio. 1986. Subacute atrazine treatment effects on rat renal functions. *Bulletin of Environmental Contamination and Toxicology* 36:325-331.

Satterlund, D.R. 1972. Wildland Watershed Management. John Wiley and Sons." Sauer, R. H. and D. W. Uresk. 1976. Phenology of steppe plants in wet and dry years. *Northwest Science* 50 (3): 133-138.

Schier, G. A. 1975. Deterioration of aspen clones in the middle Rocky Mountains. Research Paper INT-170. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station.

Schier, G. A., J. R. Jones, and R. P. Winokur. 1985. Vegetative regeneration. 29-33. In Aspen: Ecology and management in the western United States, eds. Norbert V. DeByle and Robert P. Winokur. General Technical Report RM-119. Ft. Collins, CO: United States Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Schmidt, J. L., and D. L. Gilbert. 1978. Big game of North America. Harrisburg, PA: Stackpole.

Schmidt-Nielsen, K. 1972. How animals work. Cambridge, MA: Cambridge University Press.

Schmidt-Nielsen, K. 1975. Animal physiology. Englewood Cliffs, NJ: Prentice-Hall.

Schmutz, E. M. 1967. Chemical control of three Chihuahuan Desert shrubs. *Weeds* 15:62-67.

Schmutz, E. M., D. R. Cable, and J. J. Warwick. 1959. Effects of shrub removal on the vegetation of a semidesert grass-shrub range. *Journal of Range Management* 12:34-37.

Schroeder, M. H., and D. L. Sturges. 1975. The effect on the Brewer's sparrow of spraying big sagebrush. *Journal of Range Management* 28:294-297.

Schwetz, B. A., G. L. Sparsch, and P. J. Gehring. 1971. The effect of 2,4-dichlorophenoxyacetic acid (2,4-D) and esters of 2,4-D on rat embryonal, fetal, and neonatal growth and development. *Food and Cosmetics Toxicology 9:801-817.*

Scifres, C. J. 1980. Brush management. College Station, TX: Texas A&M University Press.

Scifres, C. J., and J. C. Halifax. 1972. Development of range grass seedlings germinated in picloram. *Weed Science* 4:341-344.

Scifres, C. J., and B. H. Koerth. 1986. Habitat alterations in mixed brush from variable herbicide patterns. *Wildlife Society Bulletin* 14:345-356.

Scifres, C. J., and J. L. Mutz. 1978. Herbaceous vegetation changes following applications of tebuthiuron for brush control. *Journal of Range Management* 31:375-378.

Scott, V. E., and E. L. Boeker. 1977. Responses of Merrians turkey to pinyon-juniper control. *Journal of Range Management* 30:220-223.

Scott, V. H., and R. H. Burgy. 1956. Effects of heat and brush burning on the physical properties of certain upland soils that influence infiltration. Soil Science.

Scott, V. E., K. E. Evans, D. R. Patton, and C. P. Stone. 1977. Cavity nesting birds of North American forests. U.S. Department of Agriculture Handbook no. 511.

Sedwick, J. A., and R. A. Ryder. 1987. Effects of chaining pinyon-juniper on nongame wildlife. In Proceedings—Pinyon-juniper conference, comp. R. L. Everett, 541-551. General Technical Report INT-215. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Station.

Seibert, H. C. 1949. Differences between migrant and nonmigrant birds in food and water intake at various temperatures and photoperiods. *Auk* 66:128-153.

Severson, K. E., and A. L. Medina. 1983. Deer and elk habitat management in the southwest. *Journal of Range Management* Monograph 2. Denver CO: Society of Range Management.

Seyler, D. E., J. M. East, L. W. Condie, and J. F. Borselleca. 1984. The use of in vitro methods for assessing reproductive toxicity—dichlorophenols. *Toxicology Letters* 20:309-315.

Sharrow, S. H., and H. A. Wright. 1977a. Proper burning intervals for tobosagrass in west Texas based on nitrogen dynamics. *Journal of Range Management* 30:343-346.

Sharrow, S. H., and H. A. Wright. 1977b. Effects of fire, ash, and litter on soil nitrate, temperature, moisture, and tobosagrass production in the Rolling Plains. *Journal of Range Management* 30:266-270.

Shearer, R. C. 1975. Seedbed characteristics in western larch forests after prescribed burning. Research Paper INT-167. Ogden, UT: United States Department of Agriculture, Forest Service.

Shelby, M. D. 1988. The genetic toxicity of human carcinogens and its implications. *Mutation Research* 204:3-15.

Shelford, V. E. 1963. *The ecology of North America.* Urbana, IL: University of Illinois Press.

Sherman, H., and A. M. Kaplan. 1975. Toxicity studies with 5-bromo-3-sec-butyl-6-methyluracil. *Toxicology and Applied Pharmacology* 34:189-196.

Short, H. L., W. Evans, and E. L. Boeker. 1977. The use of natural and modified pine-juniper woodlands by deer and elk. *Journal of Wildlife Management* 41:543-559.

Shown, L. M., R. F. Miller, and F. A. Branson. 1969. Sagebrush conversion to grassland as affected by precipitation, soil and cultural practices. *Journal of Range Management* 22:303-311.

Simmons, G. 1983. Impacts of herbicides on human health—worst case analysis. U.S. Department of the Interior, Instruction Memorandum no. OR-83-270.

Skau, C. M. 1961. Some hydrologic influences of cabling juniper. Research Note 62. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Station.

Skau, C. M. 1964. Soil water storage under natural and cleared stands of alligator and Utah juniper in northern Arizona. Research Note RM-24. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Station.

REFERENCES

Skoulin, J. M. 1984. Impacts of grazing on wetlands and riparian habitat: a review of our knowledge. In Developing strategies for rangeland management. 1001-1104. National Research Council/National Academy of Sciences. Boulder, CO: Westview Press.

Skousen, J., J. N. Davis, and J. D. Brotherson. 1986. Comparison of vegetation patterns resulting from bulldozing and two-way chaining on a Utah pinyon-juniper big game range. *Great Basin Naturalist* 46:508-512.

Slobodkin, L. B., and S. Richman. 1961. Calories/gm. in species of animals. *Nature* 4785:299.

Smika, B. F., H. J. Haus, and G. A. Rogler. 1963. Native grass and crested wheatgrass production as influenced by fertilizer placement and weed control. *Journal of Range Management* 11:5-8.

Smith, A. H., N. E. Pearce, D. O. Fisher, H. J. Giles, C. A. Teague, and J. K. Howard. 1984. Soft tissue sarcoma and exposure to phenoxy-herbicides and chlorophenols in New Zealand. *Journal of the National Cancer Institute* 73:1111-1117.

Smith, B. H. 1984. Avian habitat selection in a mixed creosotebush-grassland community. Master's thesis, University of Arizona, Tucson.

Smith, C. B., and P. J. Urness. 1984. Small mammal abundance on native and improved foothill ranges, Utah. *Journal of Range Management* 37:353-357.

Smith, D. G 1966. Literature review on factors affecting shrub response to herbicides. Denver, CO: Colorado Division of Wildlife.

Somani, S. M. and A. Khalique. 1982. Distribution and metabolism of 2,4-dichlorophenol in rats. *Journal of Toxicology and Environmental Health* 9:889-897.

Sontiere, E. C., and E. G. Bolen. 1976. Mourning dove nesting on tobosa grass-mesquite rangeland sprayed with herbicides and burned. *Journal of Range Management* 29:226-231.

Sosebee, R. E. 1983. Physiological, phenological and environmental considerations in brush and weed control. In Proceedings of brush management symposium, ed. K. C. McDaniel, 27-34. Denver, CO: Society for Range Management.

Sprague, J. B. 1985. Factors that modify toxicity. In *Fundamentals of aquatic toxicology*, ed. G. M. Rand and S. R. Petrocelli. New York: Hemisphere Publishing Corporation.

Springfield, H. W. 1976. Characteristics and management of southwestern pinyon-juniper ranges: The status of our knowledge. Research Paper RM-160. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Station.

Stager, D. W., and D. A. Klebenow. 1987. Mule deer response to wildfire in Great Basin pinyon-juniper woodland. In Proceedings pinyon-juniper conference, 572-579. General Technical Report INT-215. U.S. Department of Agriculture, Forest Service.

Stark, N. M. 1977. Fire and nutrient cycling in a Douglas-fir/larch forest. *Ecology* 58:16-30.

Starkey, E. E. 1985. Impact of fire on nongame wildlife. In Rangeland Fire Effects 48-51.

Stein, W. I. 1986. Regeneration outlook on BLM lands in the Siskiyou Mountains. Research Paper PNW-349. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Stern, A. C. 1976. Air Pollution: Third Edition, Volume 1 - Air Pollutants, Their Transformation and Transport. New York: Academic Press.

Sturges, D. L. 1973. Soil moisture response to spraying big sagebrush the year of treatment. *Journal of Range Management* 26:444-447.

Sturges, D. L. 1975. Hydrologic relations on undisturbed and converted big sagebrush lands: The status of our knowledge. Research Paper RM-140. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Station.

Sturkie, P. D. 1965. *Avian physiology*. Comstock Publishing Associates. Ithaca, NY: Cornell University Press.

Sullivan, T. P. 1985. Effects of glyphosate on selected species of wildlife. In The herbicide glyphosate. Chapter 12, ed. E. Grossbard and D. Atkinson. Boston, MA: Buttersworth.

Summerfield, H. B. 1976. Effects of prescribed burning on watershed conditions. In Use of prescribed burning in western woodland and range ecosystems, A symposium, 43-46. Logan, UT: Utah State University.

Swetnam, T. 1990. Fire history and climate in the southwest United States, pp. 6-17. In Proc. of Symposium: Effects of Fire Management of Southwestern Natural Resources. USDA Forest Service. Gen. Tech. Rep. RM-191. Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado.

Szaro, R. C., P. H. Albers, and N. C. Coon. 1978. Petroleum: Effects on mallard egg hatchability. *Journal of Wildlife Management* 42:404-406.

Tabler, R. D. 1968. Soil moisture response to spraying big sagebrush with 2,4-D. *Journal of Range Management* 31:12-15.

Tanner, G. W., J. M. Inglis, and L. H. Blankenship. 1978. Acute impact of herbicide strip treatment on mixed brush white-tailed deer habitat on the northern Rio Grande Plain. *Journal of Range Management* 31:386-391.

Tarbuck, E. J., and Lutgens, F. K. 1979. *Earth science*. 2d ed. Columbus, OH: Charles E. Merrill Publishing.

Tate, R. L. 1987. *Soil organic matter*. New York: John Wiley and Sons.

Tausch, R. J. 1973. Plant succession and mule deer utilization on pinyon-juniper chainings in Nevada. Master's thesis, University of Nevada, Reno.

Tausch, R. J., and P. T. Tueller. 1977. Plant succession following chaining of pinyon-juniper woodlands in eastern Nevada. *Journal of Range Management* 30:44-49.

Tausch, R. J.; N. E. West; and A. A. Nabl. 1981. Tree age and dominance patterns in Great Basin pinyon-juniper woodlands. *Journal of Range Management*. 34(4):259-264.

Terrel, T. L. 1973. Mule deer use patterns as related to pinyon-juniper conversion in Utah. Ph.D. diss., Utah State University, Logan.

Thill, D. C., K. G. Beck, and R. H. Callihan. 1984. The biology of downy brome (Bromus tectorum). *Weed Science Society of America*, v. 32 Supplement 1:7-12.

Thomas, J. W., ed. 1979. Wildlife habitats in managed forests. Agricultural Handbook no. 553. U.S. Department of Agriculture, Forest Service.

Thomas, J. W., C. Maser, and J. E. Rodiek. 1979. Wildlife management in managed rangelands—The Great Basin of southeastern Oregon—Riparian zones. General Technical Report RNW-80. U.S. Department of Agriculture, Forest Service.

REFERENCES

Thompson, F., F. L. Leistritz and J. A. Leitch. 1990. Economic impact of leafy spurge infestations in North Dakota. Fargo: North Dakota State University. Ag. Econ. Report No. 257-S. May, 1990.

Thompson, P. 1985. *Thompson's guide to freshwater fishes.* Boston: Houghton Mifflin Co.

Tiedemann, A. R., and E. M. Schmutz. 1966. Shoot control and reseeding effects on the oak chaparral of Arizona. *Journal of Range Management* 19:191-195.

The following Tirmenstein references are for Chapter 3.

Tirmenstein, D. 1986a. *Atriplex canescens.* In Fire effects information system (data base), comp. William C. Fischer. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Science Laboratory.

Tirmenstein, D. 1986b. *Juniperous osteosperma.*

Tirmenstein, D. 1986c. *Artemisia frigida.*

Tirmenstein, D. 1987a. *Stipa comata.*

Tirmenstein, D. 1987b. *Stipa thurberiana.*

Tirmenstein, D. 1987c. *Gutierrezia sarothrae.*

Tirmenstein, D. 1987d. *Koeleria cristata.*

Tirmenstein, D. 1987e. *Stipa viridula.*

Tirmenstein, D. 1987f. *Bouteloua curtipendula.*

Tirmenstein, D. 1987g. *Potentilla fruticosa.*

Tirmenstein, D. 1988. *Quercus turbinella.*

The following Tirmenstein references are for Appendix F.

Tirmenstein, D. 1986a. *Artemisia arbuscula* ssp. *arbuscula.* In Fire effects information system (data base), comp. William C. Fischer. Missoula, MT: United States Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory.

Tirmenstein, D. 1986b. *Artemisia filifolia.*

Tirmenstein, D. 1986c. *Artemisia frigida.*

Tirmenstein, D. 1986d. *Atriplex canescens.*

Tirmenstein, D. 1986e. *Juniperus osteosperma.*

Tirmenstein, D. 1987a. *Bouteloua curtipendula.*

Tirmenstein, D. 1987b. *Bouteloua gracilis.*

Tirmenstein, D. 1987c. *Gutierrezia sarothrae.*

Tirmenstein, D. 1987d. *Koeleria cristata.*

Tirmenstein, D. 1987e. *Potentilla fruticosa.*

Tirmenstein, D. 1987f. *Rhus aromatica.*

Tirmenstein, D. 1987g. *Sarcobatus vermiculatus.*

Tirmenstein, D. 1987h. *Stipa comata.*

Tirmenstein, D. 1987i. *Stipa thurberiana.*

Tirmenstein, D. 1987j. *Stipa viridula.*

Tirmenstein, D. 1988a. *Juniperus deppeana.*

Tirmenstein, D. 1988b. *Quercus turbinella.*

Tirmenstein, D. 1988c. *Rhus glabra.*

Tirmenstein, D. 1988d. *Rhus trilobata.*

Tirmenstein, D. 1989a. *Juniperus monosperma.*

Tirmenstein, D. 1989b. *Yucca baccata.*

Tirmenstein, D. 1989c. *Yucca glauca.*

Tirmenstein, D. 1989d. *Yucca schidigera.*

Tisdale, E. W., and M. Hironaka. 1981. The sagebrush-grass region: A review of the ecological literature. Bulletin no. 33. University of Idaho. Forest, Wildlife, and Range Experiment Station.

Todd, T. L. 1962. A case of 2,4-D intoxication. *Journal of the Iowa Medical Society* 52:663-664.

Tomback, D. F. 1986. Post-fire regeneration of Krummholz whitebark pine: A consequence of nutcracker seed caching. *Madrono* 33 (2): 100-110.

Tooby, T. E., J. Lucey, and B. Stott. 1980. The tolerance of grass carp (Tenopharyngodon idella) Val., to aquatic organisms. *Journal of Fish Biology* 16:591-597.

Trlica, M. J. 1977. Distribution and utilization of carbohydrate reserves in range plants. In *Rangeland Plant Physiology*, R. E. Sosebee, et al., 73-96. Denver, CO: Society for Range Management.

Tromble, J. M. 1976. Semiarid rangeland treatment and surface runoff. *Journal of Range Management* 29:251-254.

Tromble, J. M. 1980. Infiltration rates on rootplowed rangeland. *Journal of Range Management* 33:423-425.

Tsuda, H., M. Hananouchi, M. Tatematsu, M. Hirose, K. Hirao, M. Takahashi, and N. Ito. 1976. Tumorigenic effect of 3-amino-1H-1,2,4-triazole on rat thyroid. *Journal of the National Cancer Institute* 57 (4): 861-863.

Tsuda, S., and Y. Okuno. 1985. Solvents and insecticidal efficacy of the aerosol containing tertramethrin and d-phenothrin. *Journal of Pesticide Science* 10 (4): 621-628.

Tueller, P. T. 1976. Deer range improvement and mule deer management. In Mule deer decline in the West, A symposium, eds. G. W. Workman and J. B. Low, 55-66. Logan, UT: Utah State University.

Tueller, P. T., and R. A. Evans. 1969. Control of green rabbitbrush and big sagebrush with 2,4-D and picloram. *Weed Science* 17:233-235.

Turkula, T. E. and S. M. Jalal. 1985. Increased rates of sister chromatid exchanges induced by the herbicide 2,4-D. *The Journal of Heredity* 76:213-214.

Turkula, T. E. and S. M. Jalal. 1987. Induced clastogenicity in white rats by the herbicide 2,4-D. *Cytologia* 52 (2): 275-281.

Turner, F. B., and D. C. Randall. 1987. The phenology of desert shrubs in southern Nevada. *Journal of Arid Environments* 13:119-128.

Turner, G. T. 1969. Responses of mountain grassland vegetation to gopher control, reduced grazing and herbicide. *Journal of Range Management* 22:377-383.

U.S. Department of Agriculture. 1935. Food habits of the coyote in Jackson Hole, WY. Circular No. 362. Washington, DC.

U.S. Department of Agriculture, Soil Conservation Service. 1972. Land resource regions and major land resource areas of the United States. Agriculture Handbook 296. Washington, DC: Soil Conservation Service.

REFERENCES

U.S. Department of Agriculture, Forest Service. 1976. Southern forestry smoke management guidebook. General Technical Report SE-10. Asheville, NC: U.S. Forest Service, Southeastern Forest Experiment Station.

U.S. Department of Agriculture, Forest Service. 1980. Revegetation equipment catalog. Fort Missoula, MT: Equipment Development Center.

U.S. Department of Agriculture, Soil Conservation Service. 1981. Land resource regions and major land resource areas of the United States. Soil Conservation Service Agricultural Handbook 296. Washington, DC: Department of Agriculture.

U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 1982. Siskiyou national forest aerial applicators handbook.

U.S. Department of Agriculture, Forest Service. 1984. Pesticide background statements. Vol. I, Herbicides. Agriculture Handbook no. 633. Washington, DC: U.S. Government Printing Office.

U.S. Department of Agriculture, Forest Service. 1984. Pesticide background statements. Vol. I, Herbicides (supplement). Agriculture Handbook no. 633. Washington, DC: U.S. Government Printing Office.

U.S. Department of Agriculture, Animal and Plant Health Inspection Service. 1985. Final environmental impact statement as supplemented: Gypsy moth suppression and eradication projects. Washington, DC: U.S. Government Printing Office.

U.S. Department of Agriculture, Forest Service. 1986. Pesticide background statements. Vol. I, Herbicides (supplement). Agriculture Handbook no. 633. Washington, DC: U.S. Government Printing Office.

U.S. Department of Agriculture. 1986. Memorandum to Regional Foresters, Station Directors, and Area Directors. Undated. From Allan J. West, Deputy Chief. Subject: Carcinogenicity of Atrazine.

U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 1988. Managing competing and unwanted vegetation, final environmental impact statement. Washington, DC.

U.S. Department of Agriculture, Forest Service. 1988. Vegetation management in the coastal plain/piedmont. Vol. I, Draft environmental impact statement. Management Bulletin R8-MB15. Atlanta, GA.

U.S. Department of Agriculture, Forest Service, Southern Region. 1989. Vegetation management in the Coastal Plain/Piedmont, final environmental impact statement.

U.S. Department of Commerce. 1965. Climate summary of the United States (decennial census) 1951-1960 (various States). Washington, DC: Weather Bureau.

U.S. Department of Commerce, Bureau of the Census. 1984. *Congressional district data book of the 98th Congress.* Vol. 1. Lanham, MD: Bernan Associates. Mullwood, New York: Kraus International Publications.

U.S. Department of Commerce, Bureau of the Census. 1987. Statistical abstract of the United States: 1988. Washington, DC: U.S. Government Printing Office.

U.S. Department of Energy. 1983. Bonneville Power Administration. Final environmental impact statement: Transmission facilities vegetation management program. DOE/EIS-0097-F. Washington, DC: U.S. Government Printing Office.

U.S. Department of Health and Human Services. 1985. Fourth annual report on carcinogens. Summary 1985. Washington, DC: U.S. Public Health Service.

U.S. Department of Health and Human Services. 1987. Prevention of leading work-related diseases and injuries. Morbidity and Mortality Weekly Report. Centers for Disease Control. Washington, DC: U.S. Department of Health and Human Services.

U.S. Department of the Interior, Bureau of Land Management. n.d. Fish and wildlife 2000—A plan for the future. U.S. Department of the Interior, Bureau of Land Management.

U.S. Department of the Interior. n.d. National Environmental Policy Act of 1969. Departmental Manual, Part 516 DM 1-7.

U.S. Department of the Interior, Bureau of Land Management. 1978b. Water quality manual. Section 7240.

U.S. Department of the Interior, Bureau of Land Management. 1981a. Integrated pest management manual. Section 9220.

U.S. Department of the Interior, Bureau of Land Management. 1983. Management of designated wilderness areas manual. Section 8560.

U.S. Department of the Interior, Bureau of Land Management. 1984a. National range handbook. Handbook H-4410-1.

U.S. Department of the Interior, Bureau of Land Management. 1984b. Grazing management manual. Handbook H-4120-1.

U.S. Department of the Interior, Bureau of Land Management. 1984c. Rangeland monitoring: Actual use studies. Technical Reference 4400-2.

U.S. Department of the Interior, Bureau of Land Management. 1984d. Rangeland monitoring: Utilization studies. Technical Reference 4400-3.

U.S. Department of the Interior, Bureau of Land Management. 1984e. Visual resources management manual 8400. Washington, DC.

U.S. Department of the Interior, Bureau of Land Management. 1985. Fire management manual 9210.

U.S. Department of the Interior, Bureau of Land Management. 1985. Northwest area noxious weed control program, final environmental impact statement. Washington, DC.

U.S. Department of the Interior, Bureau of Land Management. 1985a. Northwest Area noxious weed control program, final environmental impact statement.

U.S. Department of the Interior, Bureau of Land Management. 1985b. Renewable resource improvements and treatments manual. Section 1740.

U.S. Department of the Interior, Bureau of Land Management. 1985c. Renewable resource improvements, practices, and standards manual. Section 1741.

U.S. Department of the Interior, Bureau of Land Management. 1986. Supplement to the Western Oregon Program EIS: Management of Competing Vegetation. Draft Environmental Impact Statement. Washington, DC: Bureau of Land Management.

U.S. Department of the Interior, Bureau of Land Management. 1986. Visual resources inventory handbook 8410-1. Washington, DC.

U.S. Department of the Interior, Bureau of Land Management. 1987. Supplement to the Northwest Area Noxious Weed Control Program Environmental Impact Statement. Washington, DC: Bureau of Land Management.

U.S. Department of the Interior, Bureau of Land Management. 1987a. Supplement to the Northwest Area Noxious Weed Control Program, Final Environmental Impact Statement.

REFERENCES

U.S. Department of the Interior, Bureau of Land Management. 1987b. Renewable resource improvement and treatment guidelines and procedures manual. Handbook H-1740-1.

U.S. Department of the Interior, Bureau of Land Management. 1987c. Fire planning manual. Section 9211.

U.S. Department of the Interior, Bureau of Land Management. 1987d. Fire training and qualifications manual. Section 9215.

U.S. Department of the Interior, Bureau of Land Management. 1987e. Interim management policy and guidelines for lands under wilderness review manual. Handbook H-8550-1.

U.S. Department of the Interior, Bureau of Land Management. 1987f. Public Land Statistics. Washington, DC: U.S. Government Printing Office.

U.S. Department of the Interior, Bureau of Land Management. 1987g. California vegetation management, draft environmental impact statement. Washington, DC.

U.S. Department of the Interior, Bureau of Land Management. 1987h. Recreation inventory manual 8310. Washington, DC.

U.S. Department of the Interior, Bureau of Land Management. 1988a. National Environmental Policy Act handbook. Handbook H-1790-1.

U.S. Department of the Interior, Bureau of Land Management. 1988b. Prescribed fire management manual. Section 9214.

U.S. Department of the Interior, Bureau of Land Management. 1988c. Chemical pest control manual. Handbook H-9011-1.

U.S. Department of the Interior, Bureau of Land Management. 1988d. Management of designated wilderness areas manual. Handbook H-8560-1.

U.S. Department of the Interior, Bureau of Land Management. 1988e. Cultural resource management manual. Sections 8100-8160.

U.S. Department of the Interior, Bureau of Land Management. 1988f. Public land statistics: 1987. Washington, DC: U.S. Government Printing Office.

U.S. Department of the Interior, Bureau of Land Management. 1989a. California vegetation management, final environmental impact statement.

U.S. Department of the Interior, Bureau of Land Management. 1989b. Western Oregon program—Management of competing vegetation, final environmental impact statement.

U.S. Department of the Interior, Bureau of Land Management. 1990. Fire reporting System. Database on Honeywell DPS-8000 at Service Center, Denver Federal Center, Denver, CO.

U.S. Department of the Interior, Bureau of Lang Management. 1990. The State of the Public Rangelands.

U.S. Department of the Interior, Bureau of Land Management. 1990. A Strategy for Management of Special Status Fishes and Their Ecosystems on Public Lands - Draft.

U.S. Department of the Interior, Bureau of Lang Management. 1990. Use of biological control agents of pests on public lands manual 9014.

U.S. Department of Justice, U.S. Drug Enforcement Administration. 1985. Final environmental impact statement on the eradication of cannabis on federal lands in the continental United States. Washington, DC: U.S. Department of Justice.

U.S. Department of Justice, U.S. Drug Enforcement Administration. 1988. Final environmental impact statement on the eradication of cannabis on non-federal and Indian lands in the contiguous United States and Hawaii. Washington, DC: U.S. Department of Justice.

U.S. Environmental Protection Agency. 1975. Initial scientific and minieconomic review of bromacil. Washington, DC: Office of Pesticide Programs.

U.S. Environmental Protection Agency. 1978. Proposed guidelines for registering pesticides in the U.S.—Hazard evaluation: humans and domestic animals. Federal Register: 37335-37403. August 22, 1978.

U.S. Environmental Protection Agency. 1979. Protecting visibility: An EPA report to Congress. Report Number EPA-450/5-79-008. Research Triangle Park, NC: Office of Air Quality Planning and Standards.

U.S. Environmental Protection Agency. 1982. Guidance for the reregistration of pesticide products containing hexazinone. Washington, DC: Office of Pesticide Programs.

U.S. Environmental Protection Agency. 1983. Atrazine science chapters. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1983. Diuron science chapters. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1983. Guidance for the reregistration of pesticide products containing dicamba as the active ingredient. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1983. Simazine science chapters. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1983a. Atrazine science chapters. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1983b. Guidance for the reregistration of pesticide products containing dicamba as the active ingredient. Washington, DC: Office of Pesticide Programs.

U.S. Environmental Protection Agency. 1983c. Dicamba science chapters. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1983d. Diuron science chapters. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1983e. Simazine science chapters. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1984. Guidance for the reregistration of pesticide products contraining simazine as the active ingredient. Washington, DC: Office of Pesticide Programs.

U.S. Environmental Protection Agency. 1984. Summary of results of studies submitted in support of the registration of dalapon. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1984. Summary of results of studies submitted in support of the registration of dicamba. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1984. Summary of results of studies submitted in support of the registration of sulfometuron methyl. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1984. Summary of studies submitted in support of registration of diuron. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1984a. Summary of results of studies submitted in support of the registration of amitrole. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1984b. Amitrole science chapters. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1984a. Health effects assessment for benzo(a)pyrene. Cincinnati, OH: Environmental Criteria and Assessment Office.

U.S. Environmental Protection Agency. 1984b. Health effects assessment for benzene. Cincinnati, OH: Environmental Criteria and Assessment Office.

U.S. Environmental Protection Agency. 1984b. Summary of results of studies submitted in support of the registration of atrazine. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1984c. Summary of results of studies submitted in support of the registration of bromacil. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1984d. Summary of results of studies submitted in support of the registration of dalapon. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1984e. Summary of results of studies submitted in support of the registration of glyphosate. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1984f. Summary of results of studies submitted in support of the registration of hexazinone. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1984g. Summary of results of studies submitted in support of the registration of picloram. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1984h. Picloram science chapters. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1984i. Summary of results of studies submitted in support of the registration of sulfometuron methyl. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1985. Internal memorandum on the preliminary risk assessment for bromacil based on Haskel study # 893-80 in CD-1 mice, Case # 111. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1985. Internal memorandum on the consensus review of glyphosate. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1985. Pesticide fact sheet for imazapyr. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1985. Status report on the toxicological studies under review, or expected to be reviewed, for the herbicides paraquat, glyphosate, and 2,4-D. October 3rd memorandum to Charles Sherman. Washington, DC: U.S. Drug Enforcement Administration.

U.S. Environmental Protection Agency. 1985a. Risk assessment on amitrole. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1985b. Guidance for reregistration of pesticide products containing amitrole as the active ingredient. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1985a. Bromacil science chapters. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1985b. Imazapyr pesticide fact sheet. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1985c. Summary of results of studies submitted in support of the registration of triclopyr. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1985d. Hazard Evaluation Division, standard evaluation procedure, acute toxicity test for freshwater fish. EPA-540/9-85-006. Prepared by E. Zucker. NTIS PB86-129277. Washington, DC: Office of Pesticide Programs.

U.S. Environmental Protection Agency. 1986. Guidelines for the health risk assessment of chemical mixtures. Federal Register 52(185): 34014-34025. September 24, 1986.

U.S. Environmental Protection Agency. 1986. Guidance for the registration of pesticide products containing formaldehyde and paraformaldehyde. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1986. Guidelines for mutagenicity risk assessment. Federal Register 51 (185): 34006-34012. September 24, 1986.

U.S. Environmental Protection Agency. 1986. Hazard Evaluation Division standard evaluation procedure: Ecological risk assessment. Washington, DC: Office of Pesticide Programs.

U.S. Environmental Protection Agency. 1986. List of suspect or oncogenic pesticide chemicals. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1986. Standard evaluation procedure ecological risk assessment. Washington, DC: Hazard Evaluation Division, Office of Pesticide Programs.

U.S. Environmental Protection Agency. 1986. Summary of results of studies submitted in support of the registration of bromacil. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1986. Summary of results of studies submitted in support of the registration of hexazinone. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1986. Summary of results of studies submitted in support of the registration of tebuthiuron. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1986. Summary of studies submitted in support of registration of diuron. Washington, DC: Office of Pesticides and Toxic Substances.

REFERENCES

U.S. Environmental Protection Agency. 1986. Summary of studies submitted in support of the registration of triclopyr. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1986a. Letter to John Neisess, U.S. Forest Service, regarding the NOEL for dicamba. April 4, 1986. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1986a. Summary of studies submitted in support of registration of 2,4-D. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1986b. Chemical fact sheet for 2,4-D. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1986c. Internal memorandum on the carcinogenic risk assessments of 2,4-D. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1986a. EPA tox one-liner for glyphosate. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1986b. Guidance for the reregistration of pesticide products containing glyphosate as the active ingredient. Washington, DC: Office of Pesticide Programs.

U.S. Environmental Protection Agency. 1986a. Chemical information fact sheet for 2,4-D. August 1986. Washington, DC.

U.S. Environmental Protection Agency. 1986b. Summary of results of studies submitted in support of the registration of dicamba. Washington, DC: Office of Pesticide Programs.

U.S. Environmental Protection Agency. 1986c. Summary of results of studies submitted in support of the registration of diuron. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1986d. Tox 1-liner for glyphosate. Washington, DC: Office of Pesticides Programs.

U.S. Environmental Protection Agency. 1986e. Guidance for the reregistration of pesticide products containing glyphosate as the active ingredient. Washington, DC: Office of Pesticide Programs.

U.S. Environmental Protection Agency. 1986f. Summary of results of studies submitted in support of the registration of simazine. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1986g. Summary of results of studies submitted in support of the registration of tebuthiuron. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1986h. Summary of studies submitted in support of registration of triclopyr. Washington, DC: Office of Pesticide Programs.

U.S. Environmental Protection Agency. 1987. Agricultural chemicals in ground water: Proposed pesticide strategy. U.S. EPA, Office of Pesticides and Toxic Substances, Washington, D.C., 150 pp.

U.S. Environmental Protection Agency. 1987. Atrazine health advisory (draft). Washington, DC: Office of Drinking Water.

U.S. Environmental Protection Agency. 1987. Bromacil health advisory (draft). Washington, DC: Office of Drinking Water.

U.S. Environmental Protection Agency. 1987. Dicamba health advisory (draft). Washington, DC: Office of Drinking Water.

U.S. Environmental Protection Agency. 1987. Diuron health advisory (draft). Washington, DC: Office of Drinking Water.

U.S. Environmental Protection Agency. 1987. Health advisory for hexazinone (draft). Washington, DC: Office of Drinking Water.

U.S. Environmental Protection Agency. 1987. Toxicology chapter of the registration standard for tebuthiuron. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1987a. Dalapon health advisory (draft). Washington, DC: Office of Drinking Water.

U.S. Environmental Protection Agency. 1987b. Guidance for the reregistration of pesticide products containing dalapon as the active ingredient. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1987a. Health Advisory for simazine (draft). Washington, DC: Office of Drinking Water.

U.S. Environmental Protection Agency. 1987b. Summary of studies submitted in support of reregistration of simazine. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1987a. Atrazine health advisory (draft). Washington, DC: Office of Drinking Water.

U.S. Environmental Protection Agency. 1987b. Correspondence of Robert Taylor, EPA, to Kevin Cannon, Monsanto Company, regarding review of glyphosate dog study. June 9, 1987. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1988. EPA tox one-liner for atrazine. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1988. EPA tox one-liner for clopyralid. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1988. EPA tox one-liner for dicamba. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1988. EPA tox one-liner for glyphosate. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1988. Guidance for the reregistration of pesticide products containing 2,4-dichlorophenoxyacetic acid (2,4-D). Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1988. Guidance for the reregistration of pesticide products containing hexazinone as the active ingredient. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1988. Integrated Risk Information System (IRIS). Cincinnati, OH: Office of Research and Development.

U.S. Environmental Protection Agency. 1988. Summary of results of studies submitted in support of the registration of bromacil. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1988. Summary of studies submitted in support of the registration of triclopyr. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1988. Tox one-liner for mefluidide. Washington, DC: Office of Pesticides and Toxic Substances.

REFERENCES

U.S. Environmental Protection Agency. 1988a. Integrated risk information system (IRIS). Cincinnati, OH: Office of Research and Development.

U.S. Environmental Protection Agency. 1988b. EPA tox one-liner for chlorsulfuron. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1988b. EPA tox one-liner for metsulfuron methyl. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1988a. Guidance for the registration of pesticide products containing picloram as the active ingredient. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1988b. Summary of results of studies submitted in support of the registration of picloram. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1989. Hazardous Substances Databank. On-line information retrieval system. Bethesda, MD: National Library of Medicine.

U.S. Environmental Protection Agency. 1989. Lists of chemcials used as inert ingredients in pesticide formulations. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1989. Reference dose (RfD) tracking report. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1989. Supplement to Compilation of Air Pollutant Emission Factors, AP-42. Section 11.1.3, Prescribed Burning. Office of Air Quality Planning and Standards. Research Triangle Park, NC.

U.S. Environmental Protection Agency. 1989a. Information concerning simazine for the Scientific Advisory Panel. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Environmental Protection Agency. 1989b. Reference does (RfD) tracking report. Washington, DC: Office of Pesticides and Toxic Substances.

U.S. Office of Science and Technology Policy. 1985. Chemical carcinogens: a review of the science and its associated principles. Federal Register 10371-10442. March 14, 1985.

Uchytil, R. 1988. *Calamovilfa longifolia*. In Fire effects information system (data base), comp. William C. Fischer. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Science Laboratory. (In Chapter 3 of the document.)

Uchytil, R. 1988a. *Calamovilfa longifolia*. (In Appendix F of the document.)

Uchytil, Ronald. 1988b. *Hilaria mutica*.

Uechert, D. N., T. L. Whigham, and B. M. Spears. 1978. Effect of burning on infiltration, sediment and other soil properties in a mesquite-tobosa grass community. *Journal of Range Management* 31:420-425.

University of Wyoming. 1988. Wyoming weed control guide. Wyoming. Cooperative Extension Service.

Urness, P. J. 1974. Deer use changes after rootplowing in Arizona chaparral. Research Note RM-255. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Station.

Valentine, K. A. 1947. Effect of water-retaining and water-spreading structures in revegetating semidesert rangeland. Bulletin 341. New Mexico Agricultural Experimental Station.

Vallentine, J. F. 1971. Range development and improvements. 1st. ed. Provo, UT: Brigham Young University Press.

Vallentine, J. F. 1980. Range development and improvements. 2d ed. Provo, UT: Brigham Young University Press.

Vallentine, J. F. 1983. Mechanical brush control methods. In Proceedings, brush management symposium, ed. K. C. McDaniel, 53-59. Denver, CO: Society for Range Management.

Van Epps, G. A. 1974. Control of Gambell oak with three herbicides. *Journal of Range Management* 27:297-301.

Vaughan, A. 1987. Personal communication, Ecological Effects Branch, Hayard Evaluation Division, EPA.

Volk, W. A., and M. F. Wheeler, eds. 1983. Basic microbiology. 4th ed. Toronto, Ontario: J. B. Lippincott Company.

Wade, D. D., and R. W. Johnson. 1986. Effects of fire on southern pine: Observations and recommendations. General Technical Report SE-41. Asheville, NC: United States Department of Agriculture, Forest Service. Southeastern Research Station.

Wagle, R. F. 1981. Fire: Its effects on plant succession and wildlife in the Southwest. RR281. University of Arizona, Tucson.

Waldron, A. C. 1985. Minimizing pesticide exposure risk for the mixer-loader, applicator, and field worker. In Dermal exposure related to pesticide use, ed. R. C. Honeycutt, G. Zweig, and N. N. Ragsdale. ACS symposium series no. 273. American Chemical Society.

Wallis, W. E., A. von Poznak, and F. Plum. 1970. Generalized muscular stiffness, fasciculations, and myakymia of peripheral nerve origin. Archives of Neurology 22:430-439.

Ward, A. L. 1973. Sagebrush control with herbicide has little effect on elk calving behavior. Research Note RM-240. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Station.

Warren, P. L., and S. L. Anderson. 1985. Gradient analysis of a Sonoran Desert wash. In Riparian ecosystems and their management. General Technical Report RM-120:150-155. U.S. Department of Agriculture, Forest Service.

Wauchope, R. D., D. Goss, A. Hornsby. 1991. The Soil Conservation Service/Agriculture Research Service/Cooperative Extension Service pesticide properties database. Submitted to Rev. Environ. Contamin. Toxicol.

Weaver, H. R., and W. L. Haskell. 1967. Some fall foods of Nevada chucker partridge. *Journal of Wildlife Management* 31:582-584.

Weed Science Society of America. 1979. Herbicide handbook. 4th ed. Champaign, IL.

Weed Science Society of America. 1983. Herbicide handbook, 5th ed. Champaign, IL: Weed Science Society of America.

Weeks, A. 1985. Unpublished data, National Institutes of Health.

Weininger, R. B., G. Davis, and C. D. Hawks. 1987. Herbicides and cancer. *Journal of the American Medical Association* 257 (17): 2292.

Weins, J. A., and G. S. Innis. 1974. Estimation of energy flow in bird communities: A population bioenergetics model. *Ecology* 55:730-746.

Wells, C. G., R. E. Cambell, L. F. DeBano, C. E. Lewis, R. L. Frederudson, E. C. Franklin, R. C. Froelich, and P. H. Dunn. 1979. Effects of fire on soil. General Technical Report WO-7. Washington, DC: U.S. Department of Agriculture, Forest Service.

Welty, J. C. 1962. *The life of birds*. Philadelphia: W. B. Saunders.

Wernert, S. J., ed. 1982. *North American wildlife.* Pleasantville, New York: Reader's Digest Association Inc.

West, N. E. 1968. Rodent-influenced establishment of ponderosa pine and bitterbrush seedlings in central Oregon. *Ecology* 49 (5): 1009-1011.

West, N.E., ed. 1983. Ecosystems of the World 5, Temperate Deserts and Semi-Deserts. Elsevier Scientific Publishing Co., Amsterdam, Netherlands.

West, N. E. 1984. Successional patterns and productivity potentials of pinyon-juniper ecosystems. In Developing strategies for rangeland management, 1301-1332. National Research Council/National Academy of Sciences. Boulder, CO: Westview Press.

West, N. E., and M. A. Hassan. 1985. Recovery of sagebrush-grass vegetation following wildfire. *Journal of Range Management* 38:131-134.

West, N. E. and N. Van Pelt. 1987. Successional patterns in pinyon-juniper woodlands, pp. 43-52. In Proc. Pinyon-Juniper Conference. USDA Forest Service. Gen. Tech. Rep. INT-215. Intermountain Research Station. Ogden, Utah.

Whitaker, J. O., Jr. 1980. *The Audubon Society field guide to North American mammals.* New York: Alfred A. Knopf.

White, R. S., and P. O. Cusive. 1983. The effects of prescribed burning on silver sagebrush. *Journal of Range Management* 36:611-613.

Whitney, S. 1985. *Western forests: The Audubon Society nature guides.* New York: Alfred A. Knopf.

Whitson, T. D., and H. P. Alley. 1984. Tebuthiuron effects on Artemisia spp. and associated grasses. *Weed Science* 30:180-184.

Wicks, G. A., C. R. Fenster, and O. C. Burnside. 1969. Selective control of plains pricklypear in rangeland with herbicides. *Weed Science* 17:408-411.

Wiklund, K. and L. E. Holm. 1986. Soft tissue sarcoma risk in Swedish agricultural and forestry workers. *Journal of the National Cancer Institute* 76 (2): 229-234.

Wilbert, D. E. 1963. Some effects of sagebrush chemical conduct on elk distribution. *Journal of Range Management* 16:74-78.

Wildlife Management Institute. 1980. *Big game of North America. Ecology and Management.* Stackpole Books.

Williams, G., G. F. Gifford, and G. B. Coltharp. 1969. Infiltrometer studies on treated vs. untreated pinyon-juniper sites in Utah. *Journal of Range Management* 22:110-114.

Williams, G., G. F. Gifford, and G. B. Coltharp. 1972. Factors influencing infiltration and erosion on chained pinyon-juniper sites in Utah. *Journal of Range Management* 25:201-205.

Williams, Jack E., David B. Bowman, James E. Brooks, Anthony A. Echelle, Robert J. Edwards, Dean A. Hendrickson, and Jerry J. Landye. 1985. Endangered Aquatic Ecosystems in North American Deserts with a List of Vanishing Fishes of the Region. Arizona-Nevada Academy of Science.

Wimer S. K., J. K. Ward, B. E. Anderson, and S. S. Waller. 1986. Mefluidide effects on smooth brome composition and grazing cow-calf performance. *Journal of Animal Science* 63:1054-1062.

Wink, R. L., and H. A. Wright. 1973. Effects of fire on an Ash juniper community. *Journal of Range Management* 26:326-329.

Winkler, G. 1987a. Aristida purpurea. In Fire effects information system (data base), comp. William C. Fischer. Missoula, MT: United States Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory.

Winkler, G. 1987b. *Buchloe dactyloides.*

Winkler, G. 1987c. *Poa fendleriana.*

Wolfe, H. R. 1972. *Protection of workers from exposure to pesticides. Pest Control* 40 (2): 17-18.

Wolfe, N. L., R. G. Zepp, J. A. Gordon, and R. C. Fincher. 1976. N-nitrosamine formation from atrazine. Bulletin of Environmental *Contamination and Toxicology* 15 (3): 342-347.

Wolfsdorf, J. 1976. Kerosene intoxications: an experimental approach to the etiology of the CNS manifestations in primates. *Journal of Pediatrics* 88 (6): 1037-1040.

Woodward, D. F. 1976. Toxicity of the herbicides dinoseb and picloram to cutthroat (Salmo clarki) and lake trout (Salvelinus namaycush). *Journal of the Fisheries Research Board of Canada* 33 (8): 1671-1676.

Woodward, D. F. 1979. Assessing the hazard of picloram to cutthroat trout. *Journal of Range Management* 32 (3): 230-232.

World Health Organization. 1984. Environmental health criteria 29: 2,4-dichlorophenoxyacetic acid (2,4-D). Geneva, Switzerland.

Worthing, C. R. 1983. The pesticide manual, a world compendium. 7th ed. British Crop Protection Council.

Wright H. A., and A. W. Bailey. 1980. Fire ecology and prescribed burning in the Great Plains—A research review. Ogden, UT: General Technical Report INT-77. U.S. Department of Agriculture, Forest Service, Intermountain Research Station.

Wright, E., and W. B. Bollen. 1961. Microflora of Douglas-fir forest soil. *Ecology* 42:825-828.

Wright, H. A. 1970. A method to determine heat-caused mortality in bunchgrasses. *Ecology* 51 (4): 582-587.

Wright, H. A. 1971. Why squirreltail is more tolerant to burning than needle-and-thread. *Journal of Range Management* 24 (4): 277-284.

Wright, H. A. 1974. Effect of fire on southern mixed prairie grasses. *Journal of Range Management* 27:417-419.

Wright, H. A. 1974a. Effect of fire on southern mixed prairie grasses. *Journal of Range Management* 27:417-419.

Wright, H. A. 1974b. Range burning. *Journal of Range Management* 27:5-11.

Wright, H. A. 1980. The role and use of fire in the semidesert grass-shrub type. General Technical Report INT-85. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT.

Wright, H. A. 1985. Effects of fire on grasses and forbs in sagebrush-grass communities. In Rangeland fire effects: A symposium, eds., K. Sanders, and J. Durham 12-21. U.S. Department of the Interior, Bureau of Land Management. Boise, ID: Idaho State Office.

Wright, H. A. 1990. Role of fire in the management of southwestern ecosystems, pp. 1-5. In Proc. of Symposium: Effects of Fire Management of Southwestern Natural Resources. USDA Forest Service. Gen. Tech. Rep. RM-191. Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado.

REFERENCES

Wright, H. A., and A. W. Bailey. 1980. Fire ecology and prescribed burning in the Great Plains—A research review. General Technical Report INT-77. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT.

Wright, H. A., and A. W. Bailey. 1982. *Fire ecology*. United States and southern Canada. New York: John Wiley and Sons, Wiley-Interscience Publication.

Wright, H. A., F. M. Churchill, and W. C. Stevens. 1976. Effects of prescribed burning on sediment, water yield, and water quality from dozed juniper lands in central Texas. *Journal of Range Management* 29:294-298.

Wright, H. A., L. F. Neuenschwander, and C. M. Britton. 1979. The role and use of fire in sagebrush-grass and pinyon-juniper plant communities: A state-of-the-art review. General Technical Report INT-58. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT.

Wright, J. R., and F. H. Siddoway. 1972. Improving precipitation-use efficiency on rangeland by surface modification. *Journal of Soil and Water Conservation* 27:170-174.

Wright, J. R., and L. M. White. 1974. Interseeding and pitting on a sandy range site in eastern Montana. *Journal of Range Management* 27:206-210.

Yates, W. E., N. B. Akesson, and D. E. Bayer. 1978. Drift of glyphosate sprays applied with aerial and ground equipment. *Weed Science* 26 (6): 597-604.

Yoakum, J., R. E. Eckert, Jr., and G. C. Christensen. 1969. Management and research on meadowlands in Nevada. In 6th biennial western states sage grouse workshop, 141-147. WY: Rock Springs.

Yoakum, J. D. 1975. Antelope and livestock on rangelands. *Journal of Animal Science* 40:985-988.

Young, J. A., and J. D. Budy. 1987. Energy crisis in 19th century Great Basin woodlands, pp. 23-28. In Proc. Pinyon-Juniper Conference. USDA Forest Service. Gen. Tech. Rep. INT-215. Intermountain Research Station. Ogden, Utah.

Young, J. A., R. A. Evans, and R.E. Eckert, Jr. 1969. Wheatgrass establishment with tillage and herbicides in a mesic medusahead community. *Journal of Range Management* 22:151-155.

Young, J. A., and R. A. Evans. 1972. Conversion of medusahead to downy brome communities with diuron. *Journal of Range Management* 25:40-43.

Young, J. C. and S. U. Khan. 1978. Kinetics of nitrosation of the herbicide glyphosate. *Journal of Environmental Science and Health* B13 (1): 59-72.

Young, R. P. 1986. Fire ecology and management of plant communities of Malheur National Wildlife Refuge southeastern Oregon. Unpublished Ph.D. thesis. 169 p. Oregon State University.

Young, S. P., and H. H. T. Jackson. 1951. *The clever coyote*. Harrisburg, PA: Stackpole Co.

Zar, J. H. 1968. Standard metabolism comparisons between orders of birds. *The Condor* 10 (3):278.

Zimmerman, G. T. 1989. Personal communication. Regional fire management coordination. Denver, CO: U.S. Department of Interior, National Park Service, Rocky Mountain Region.

Zimmerman, G. T. 1989. Personal conversation. Regional fire management coordinator. Denver, CO: USDI, National Park Service, Rocky Mountain Region.

Zwolinski, M. J., and J. H. Ehrenreich. 1967. Prescribed burning on Arizona watersheds. In *Proceedings of the tall timbers fire ecology conference* 7:195-205.

Zwolinski, M. J. 1990. Fire effects on vegetation and succession, pp. 18-24. In Proc. of Symposium: Effects of Fire Management of Southwestern Natural Resources. USDA Forest Service. Gen. Tech. Rep. RM-191. Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado.

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